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PLANT BREEDING IN THE SOVIET UNION.

ACHIEVEMENTS, ORGANIZATION AND FUTURE PROGRAMME OF THE INSTITUTE OF PLANT INDUSTRY.

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INTRODUCTION.

The 15th anniversary of the October Revolution has been suitably commemorated by the publication of an Anniversary Number of the new journal " Plant Industry in U.S.S.R.", one of the many series of which the Bulletin of Applied Botany, of Genetics and Plant Breeding, the organ of the Institute of Plant Industry, is now comprised. The number consists of a series of articles by specialists in the various branches, outlining the achievements of different sections of the Institute since the Revolution. In this way the opportunity is presented for the first time of gaining a comprehensive picture of the numerous activities of the Institute of Plant Industry. The Institute, under the direction of Prof. N. I. Vavilov, has in the past fifteen years succeeded in organizing the greatest experiment in plant breeding which the world has yet witnessed. The Soviet breeders have realized the inadequacy of the breeding material at their disposal and have made a systematic study of the economic plants of the whole world with the object of making a collection as complete as possible on which to base the breeding work of the future. These studies have led to the discovery of the centres of origin of the main cultivated plants and to the further discovery that these centres are at the same time the points at which the greatest number of forms and characters of the plant concerned are concentrated and so represent the source of the most valuable initial material for plant breeding. This material has been assembled in the Soviet Union and subjected to systematic study, on the basis of which monographs on the systematics of the primary crop plants have been compiled or are in the course of preparation. The material is retained in the living state and has been distributed to the appropriate climatic zones of the Union, whereby living museums of all plants of economic interest to the U.S.S.R. have been formed. Each of these world collections, in most cases unrivalled in completeness by any other collection in the world, presents opportunities for breeding on a scale beyond the dreams of breeders of previous generations.

In view of these vast new opportunities the breeding work of the Soviet Union has been entirely revised. A conference on the Planning of Breeding and Genetic Investigations was held in Leningrad on June 25-29, 1932, at which Prof. Vavilov outlined the programme of research in general and specific crop genetics which will be put in to force during the second Five Year Plan. This Congress effected the reorganization of the genetical institutions and the adoption of the new system of Breeding Centres. In this way it has been possible to overcome the tendency to scatter the breeding work amongst separate institutions, with its attendant difficulties, such as excessive specialization, and undue limitation of the scope of the work. Under the new system many of the outlying stations are not intended to undertake the actual genetical work but will receive hybrid material from the Breeding Centre and work it out under the direction of the Centre or of some large breeding institute.

In his address to this Congress Prof. Vavilov discussed the general principles of genetic investigation in a way which is applicable not only to Soviet breeders but to breeders and geneticists in the whole world. The address is published *in extenso* in the congress report and is followed by the detailed programme for work on the individual plants and problems. These two contributions are of such inestimable value to any breeder about to prepare or revise his breeding programme that the Imperial Bureaux of Plant Genetics have deemed it desirable to make them generally available to a wider range of readers. They have been translated into English and in an almost unabridged form constitute the nucleus of the present publication. In many places this material has been enlarged upon by reference to the other articles appearing in the Anniversary Number ; a list of the papers consulted appears in the bibliography. Abridged translations of these papers are available on loan.

A.—ACHIEVEMENTS SINCE THE REVOLUTION.

Plant Resources as Initial Material for Breeding.

The former Bureau of Applied Botany had already begun the collection of cultivated plants from different parts of the world but these collections were of a very limited and fragmentary nature and it was not until the reorganization subsequent to the Revolution and the accession of Vavilov to the directorship that the studies were extended so as to embrace the plant resources of the whole world. As already mentioned in the introduction, certain parts of the world were found to be key regions, where the maximum diversity of forms and characters of whole groups of cultivated plants is concentrated.

South-west Asia proved to be the centre for soft and *compactum* wheats, rice, small-seeded flax, small-seeded peas, lentil, broad bean, *Lathyrus*, gram, poppy, Asiatic cotton, apricot, almond, etc.

South-eastern Asia proved to be the centre of concentration of characters of the naked oats and barleys, dwarf barleys, millet, soya bean, and many cruciferous root crops.

The Mediterranean countries are the centre of various species of cultivated onions, *Phaseolus*, peach, olive, fig, *Avena byzantina*, large-seeded beans, lentil, flax, sulla, etc.

The north-eastern mountainous region of Africa (mainly Abyssinia) is the centre of diversity of the hard wheat group, the hulled barleys, special groups of peas, oats and various other crops.

The mountain regions of South America and Mexico have proved to be the centre of diversity of the characters of the potato, groundnut, maize, pumpkins, tobacco, American cotton, sunflower, etc.

These studies have given the real indication of new sources of most suitable material to replace and improve the present crops, and to introduce new crops such as rubber plants, essential oil plants, new fibre, oil and protein-bearing plants and new fodder plants. The material was collected by means of letters of request, personal conversations, exchange of material and by expeditions, the latter being directed towards the centres of concentration of the diversity of the characters. Expeditions have been sent to :—

(1) South-west Asia : Afghanistan (Vavilov, 1916), Pamir (Vavilov and Gorbunov, 1927—results on wheat published), Kashmir (Vavilov and Popov, 1930—part of the results published), Persia (Vavilov, 1916, E. Černjakovskaja, 1926-27—results published), western and central parts of Asia Minor (Zhukovsky, 1925-27—results partly published), India and Ceylon (Markovič, 1926-28).

(2) South-east and South Asia : Java (Markovič), Mongolia (Pissarev, 1922), Japan (Markovič, Sinskaia and Vavilov).

(3) The Mediterranean countries : Greece, Italy, Spain, Portugal, Sicily, Sardinia, Crete, Cyprus, Morocco, Algeria, Tunis, Syria, Palestine, Transjordan (Vavilov, 1927, results partly published).

(4) North-eastern mountain region of Africa : Abyssinia, Eritrea, Somaliland (Vavilov, 1927—partly published).

(5) Mountain regions of Central and South America : Mexico, Guatemala, Colombia, Bolivia, Peru, Chile (Bukasov, Voronov, Juzepczuk, 1925-27—results published).

In addition to this the whole of the Soviet Union was studied and the local material collected, expeditions being sent to the Transcaucasian republics (various workers, part of the results published), to the Central Asiatic section (various workers), to Altai (Sinskaia, Gorbunov, results published), to Syria and the Far East (various workers) and to the northern section of the Union (various workers), etc.

There still remain certain countries to be studied, viz. China, Indo-China, Hindustan, Arabia, South Africa, Uganda, Brazil, although a certain amount of material from these countries has already been obtained by other means.

The collection resulting is for some crops better than that of the United States Department of Plant Industry at Washington, e.g. 29,200 wheats as compared with 25,000. The main distinguishing feature of the collections is that they are in the live state and so serve as a store of material, embracing over 200 crops and a total of over 150,000 specimens, of wheat alone 29,200, of barley 13,000, oats over 9,000, maize over 9,000, beans 20,000, potatoes 1,000, and so on.

Wheat.

Different countries and regions have different ecological conditions and correspondingly different forms of wheat. The object of studying the entire world collection is to choose the most favourable for cultivation in the Union. Therefore in Gandgins in 1928-1931, 5,000 specimens were sown yearly, subjected to observation, harvest and threshing. Specimens best illustrating the ecological type of each country were selected, giving in all 300 which were distributed in spring 1931 to 30 different breeding institutions for further study and utilization. A somewhat smaller collection was distributed in autumn of the same year for autumn sowing. The study of these specimens in the field is done collectively in conjunction with the Institute of Plant Industry—and under the direction of K. A. Flaksberger. The establishment of the field types is in the hands of M. M. Jakubziner, and the rest is in charge of the staff of the wheat section of the Institute. V. E. Pissarev is in charge of the actual breeding section of the work.

Flaksberger's studies on wheat have shewn it to be a plant of high ecological specialization and exceptional polymorphism and of great plasticity and adaptability. Direct introduction of foreign wheats is therefore not possible. Moreover many of the best local wheats, especially the selections of the stations such as Saratov, are equal or even superior in quality to the famous North American varieties ; some of them have the highest protein content in the world, some are extremely cold resistant, while others mature earlier than the earliest Australian varieties, although they are later than the wheats from India and Arabia. All these wheats are however defective in certain characters, such as shedding, lodging, late maturity, small grain, low yield, susceptibility to fungous attack. The solution therefore lies not in replacing them by foreign wheats, but by hybridizing them with suitable foreign wheats from the world collection.

The world collection of wheats has revealed new species hitherto unknown, e.g. Vavilov's *Triticum persicum*, an endemic Transcaucasian species, discovered in 1918, similar to the *vulgare* group but with 28 chromosomes, growing in regions up to 900 m. and very resistant to rust and mildew ; Zhukovsky's *T. Timopheevi*, endemic for Georgia, resembling spelt wheats but so far completely immune to rust ; Dekaprelevitch's " macha," not yet fully investigated. Several hundred new botanical varieties of wheat have been found ; in Armenia and the Nakhičevan circle has been found wild *T. dicoccoides*, formerly regarded as endemic for Syria and Palestine, of interest for breeding on account of its resistance and tolerance of unfavourable conditions ; the wheats of Abyssinia have displayed remarkable earliness and many other interesting characters (results published) ; those of Egypt are very early and have very short grains but are susceptible to rust ; those of Asia Minor represent several types, with different degrees of straw strength, form of grain, etc. ; those of Syria, Palestine and Transjordan have been described (1932), those of Algeria, Morocco and Tunis are mainly medium early and medium late, with tall, strong straw, rather resistant to rust and large grained ; those of Italy are fairly strong strawed, but subject to shedding ; those of the Mediterranean islands are described in a publication now in the press by L. Schreiber, those of Afghanistan were described by Vavilov and Kobelev, early, drought resistant, non-shedding, some cold resistant. The Dutch and Scandinavian wheats have good straw, do not shed, give high yields and large grains, but are late, moisture-loving and of poor quality. Such descriptions have been made for the wheats of nearly all countries and indicate that foreign wheats also, valuable in certain features, are deficient in others and are of use only for hybridization.

Pissarev has made extensive use of Novinka, a wheat characterized by earliness, fairly large grains and higher yield than the northern early forms, but shedding badly ; having been obtained from Prelude × Preston it contains in its parentage Onegin, Siberian Galician and Indian wheats.

This wheat he crossed with the Scandinavian winter wheats Grenadier, Thule, etc. and obtained non-shedding spring wheats, with large ears, giving 15 - 20 per cent higher yields than Novinka in field tests in 1931.

The wheats typical for each country have been obtained and form a collection consisting of about 300 spring and 200 winter wheats, which have been distributed to the various breeding institutions of the Union, of which over 40, in the most widely separated regions of the Union, are now in possession of full collections, constituting their initial breeding material. The Shatilov Station, as the result of examination of these 500 types, has concentrated its attention on 16 types from Abyssinia, China, Manchuria, Spain, Portugal, Syria, Asia Minor, Cyprus, Afghanistan, Switzerland and Canada, and other stations have acted similarly, whilst at the same time data are sent to the Institute of Plant Industry where records of the behaviour of the world collection over the whole Union are kept.

The world collection of wheats, represented by 5,000 samples, was sent to Lyssenko and sown after vernalization at Odessa, Saratov, Omsk, North Kazakstan, in the Sovkhoz " Giant " and at Detskoe Selo, as well as smaller samples at other points. The Saratov Institute of Irrigated Grain Culture has started special breeding work with the 5,000 world specimens and wild wheats have also been utilized for crossing with cultivated ones.

Oats.

The oat section, especially the work of A. J. Mordvinkina, has succeeded in isolating forms of *Avena byzantina* sufficiently hardy to be winter sown in Transcaucasia, and others possessed of greater resistance to drought, excessive salts and fungous diseases (leaf rust and bunt) than the European oats ; these new forms will be employed for crossing with the Russian oats and direct introduction to the more southerly regions (Transcaucasia). In 1931 eleven new forms were distributed for trial in various places and to Gandgins for multiplication. A work on the drought resistant Mediterranean oats is in preparation. By crossing a Mediterranean oat with the American White Tartar a new form excelling the standards in yield, drought resistance and immunity has been produced. Its yield was 18 per cent higher and it ripened 9 days earlier.

Barley.

Under A. A. Orlov the barley section has terminated the investigation of the whole world collection, consisting of over 13,000 specimens and embracing barleys from almost every country in the world. The conclusions reached were that all barleys, cultivated and wild, constitute a single species, which falls into three sub-species, 6-rowed, 2-rowed and intermedium ; there are two centres of diversity, the main one in south-west Asia (Afghan centre, including Abyssinia) and a subsidary one in south-east Asia (China and Japan). The cultivated barleys of the following countries are of most interest :—

(1) Arabia—earliest, most drought resistant, very large grain and relatively high yield.
(2) Asia Minor—strong straw, large grain, relatively drought resistant and productive.
(3) Abyssinia—large grain, strong straw, relatively productive, even in very northern latitudes, gives grain of good malting quality in White Russia.
(4) Mediterranean—large grain and drought resistant.
(5) Syria and Palestine—large grains, resistant to drought and fungous diseases.
(6) China—early, naked grains, strong straw and adapted to northern conditions.
(7) India—early, strong straw, almost round grains.
(8) Afghanistan—early, drought resistant and grain of good shape.

The best types from all countries have been selected, forming a most valuable breeding collection of 315 types which are being grown at the North Caucasus Division of the Institute of Plant Industry. They are also being tested at 25 different breeding stations in all parts of the Union. From the point of view of extending barley cultivation northward, the barleys of China, Abyssinia and Arabia are the most valuable ; for malting purposes, those of Abyssinia and Asia Minor ; for dry regions, those of Arabia.

The barley section has isolated high-yielding barleys which have already been distributed ; in this connexion the naked barleys of Asia Minor and Italy and also the 2-rowed Armenian barleys are of interest. A description of the main forms has been published, also a popular bulletin describing the main barleys for the U.S.S.R. and their cultivation.

Maize.

The maize section under N. N. Kuleshov has selected from the world collection various valuable forms—extremely early, ripening in 70 days, making it possible to cultivate maize much further north ; amongst these are forms with the cob attached high on the stem. The best forms have been handed on for trial to the zonal station and the net of variety tests.

The discovery of varieties which remain green to maturity is of especial interest for silage.

The best sweet maize for different parts of the Union, both for table and canning purposes, has been selected. A large collection of American and West European varieties has been studied in North Caucasus, white dent for industrial and yellow dent for fodder purposes, and certain specimens proved relatively resistant to the European corn borer.

In 1931, 150 specimens of aboriginal Indian varieties were obtained by Kuleshov on his journey to the United States of America, together with 120 of the new hybrids of inbred strains. From the Indian material starchy types excelling Ivory King in quality and with much higher insertion of the cob were found.

It is proposed to introduce the male-sterile form with sterile male inflorescence and in this way simplify breeding methods.

Buckwheat.

Under E. A. Stoletova 7 specimens have been selected from the collection on account of their superiority in such points as yield and earliness, giving 90-100 grm. in 1930 in comparison with 50 and 60 grm. respectively for two well-known varieties. The material is at present being multiplied.

Two articles on buckwheat have been published.

Rye.

Inbreeding was carried out with rye through the greatest number of generations and it was proved that by this means it is possible to isolate recessive characters which by ordinary selection methods cannot be obtained. Thus low-strawed forms with strong straw, with augmented leaf production, of interest for the production of rye for hay, and forms immune to mildew, rust etc. have been isolated. It is thus already possible to appreciate the value of inbreeding in rye breeding by the isolation of recessive characters of practical value.

Swedes.

A study of the method of inbreeding has shown that close breeding is quite successful, in which case the plant does not suffer the degeneration which results from continued inbreeding. Even this method proved however to have no advantage over spatial isolation. The method was therefore tried on turnips and rape.

The variation of quantitative characters was also studied. Crosses were made between forms of the Krasnosel swede whose dry content has been raised by selection and Swedish forms, with the object of raising their yield and studying the inheritance of individual characters.

Herbage and forage plants.

The section of herbage plants, under the direction of P. P. Zvorykin and V. A. Kuznetzov, has carried out the following studies.

T. N. Erkina has surveyed and classified Sudan grass and has selected many forms from a large collection. Fifteen of these forms represent valuable varietal material suitable for mowing, silage and pasture, more particularly in arid zones. In the spring of 1931 these forms were handed over to various departments of the Institute of Plant Industry for reproduction and during the current year they have been introduced into the State Varietal Service. As the result of this study Erkina has produced a pamphlet on " Sudan grass " containing results of

field trials over a period of five years with particular reference to the biology, morphological description, taxonomical classification, fodder evaluation and agronomical treatment. In a paper by A. V. Talanova with reference to the geographical aspects of the places chosen for varietal testing the most favourable conditions for the cultivation of this grass, a recent introduction to U.S.S.R., for hay or seed purposes are outlined.

With *Melilotus alba* and *M. officinalis* extensive research has been carried out on the agricultural and botanical aspects under various climatic conditions, together with a preliminary evaluation of their fodder quality and the detection of coumarin-free forms. In 1931, V. V. Suvorov studied the composition of the strain collection of *Melilotus* and produced a paper " On breeding *Melilotus* " which included details on breeding methods. In addition, V. A. Kuznetzov has compiled a guide for the determination of *Melilotus* species in the Soviet Union which is issued by the Institute of Plant Industry together with general instructions on collecting seed from wild herbage plants. In collaboration with a group from the Section of Varietal Testing, more than 150 experimental farms have been organized under various geographical conditions where varieties and species of annual and perennial herbage plants including *Melilotus* are being tested.

L. P. Bordakov has collected more than 2,000 samples of lucerne. As a result of a study of blue lucerne some forms of great value for agriculture have been bred, namely, more tender Provence types, adequately productive and winter resistant Central Asiatic, etc. Selected forms are being reproduced in North Caucasus. Extensive tests of lucerne hybrids in comparison with races of blue lucerne have been carried out ; although less productive these hybrids are more winter resistant and therefore acquire greater importance in regions with severe winter conditions. Bordakov has also published " Field identification of lucerne." At the Maikop and North Caucasian Departments of the Institute of Plant Industry have been bred forms of yellow lucerne which are more erect, leafy, and have a higher seed yield. The cause of the low seed yield of this yellow lucerne is under investigation. Some annual lucernes which would appear to be good pasture forms are also being studied, e.g. *Medicago orbicularis* and *M. arabica*. As a result of his work on lucerne, Bordakov has published a popular pamphlet " Lucerne " in which is presented a description of the most valuable races of blue lucerne and a review of the agronomical technique of its cultivation for hay and for seed.

At the Ukrainian Department of the Institute of Plant Industry a study has been made of a strain collection of sainfoin (*Onobrychis sativa*) which includes valuable Armenian forms with good forage quality and better aftermath formation. These types have been handed over to the State Varietal Service for testing and are also being multiplied. A synopsis of literature on the cultivation of sainfoin and a description of its botanical forms was prepared for the press in 1932 by A. G. Khinchuk.

The analysis of a world collection comprising about 3,000 samples of spring vetch (*Vicia sativa*) by A. Y. Tupikova has resulted in a systematic classification of this species and a preliminary evaluation of its fodder and grain qualities under various geographical conditions. Forms which appear to be of great value for the Soviet Union have been selected for further multiplication. These include Bulgarian, Swedish, Czechoslovakian and German varieties. Soviet strains are of great value for internal use in the Soviet Union. Selected varieties have not been widely used within the Union up to the present, seed material being represented by local agricultural strains. These latter are, however, very heterogeneous in various characters. Tupikova has investigated the spring vetches of the Union and has classified various types according to the regions of their cultivation and the degree of contamination with weeds. This study enables seed growing associations to purchase less contaminated seed. As a result of studying field vetches a number of valuable forms have been selected including *V. pannonica* and various forms of *V. sativa*. Papers on " Central Asiatic vetch " and a " Report on the investigation of spring vetches of the U.S.S.R.," have been prepared for the press.

A collection of 150 samples of Teff grass (*Eragrostis abyssinica*) has been studied with special reference to its agricultural botany and sub-division into types ; forms notable for early habit and productivity have been selected for use in certain parts of Ukraine, North Caucasus, South-west Siberia, Kazakstan and Central Asia. This grass is of special interest when sown in mixtures with lucerne in cotton crop rotations.

A brigade of the Institute of Plant Industry under the direction of P. P. Zvorykin has planned the distribution of herbage plants in the Soviet Union according to their utilization for hay or silage and during the winter and summer seasons. This has been published as a special issue from the Institute of Plant Industry entitled " Information on the distribution of agricultural plants among the administrative and ecological regions of U.S.S.R."

The method of inbreeding has been found to be of great value when applied to the breeding of herbage plants, e.g. forms with very valuable recessive characters were revealed in *Trifolium hybridum* among legumes and in *Phleum pratense* among grasses. Forms of *Trifolium pratense* have been bred with a short corolla facilitating pollination by honey bees with the result that the seed yield may be considerably increased. Valuable forms of *Trifolium hybridum* with abundant leaf formation and various hay and pasture types of *Phleum pratense* have been produced by the inbreeding method. It is considered therefore that this method should be further employed in the breeding of herbage plants.

A section of the Breeding Department has been concerned with the breeding of field peas (*Pisum arvense*) suitable for forage purposes with the object of replacing vetch as hay. A number of strains which have been bred are superior in hay yield to local peas by 85 per cent and to local vetch by 40 per cent. Field peas have been specially selected for smallness of seed to enable them to compete with vetch.

Vegetables.

An agro-botanical study of the main vegetable crops has been carried out, including cabbage, tomato, carrot, pepper, egg plant, onion, beet, etc. The best varieties for the Union and for breeding have been selected from the world collection, e.g. 15 varieties of tomato, including forms suited to the south, and early and drought resistant forms of interest for the north.

Peppers producing paprika more piquant than the standard varieties have been selected ; the variety Pimento, with very regular, smooth fleshy fruits, has been introduced for canning.

Chinese onions have been introduced.

Annually 2,000 specimens of different vegetables are sent out by this section to different experiment stations and scientific institutions.

The Steppe division of the Institute of Plant Industry has selected a Boston cucumber relatively drought resistant and uniform in shape, and Egyptian beet of flattened shape and intense pigmentation, a Nantes carrot of high quality on account of the retention of the typical form of the root, drought resistance and good keeping capacity.

Cucurbits.

The cucurbit group under K. I. Pangalo has selected some perfectly new varieties of exceptional merit from the world collection ; about 20 varieties of melons, water melons and pumpkins suitable for general distribution have been discovered in this way. As they stand, these varieties are superior to the ones in cultivation in the U.S.S.R., and are being multiplied for distribution without further breeding. Pangalo has published full accounts of this work, with descriptions and illustrations of the 80 chief varieties of water melons, melons and pumpkins for the U.S.S.R.

Breeding has been carried out on luffa, especially for types suitable for use in the railway industry as tow for padding.

Potatoes.

Scientific research on the potato was started in 1921, by making a collection of the varieties cultivated in all parts of the world. A very extensive collection was obtained from foreign institutes, private individuals and seed firms.

The first necessity was a revision of systematics which, when worked out resulted in 1923 in Bukasov's " Potato varieties and their classification." Many popular articles introducing the Russian reader to foreign work on virus diseases were also published, as well as a manual on potato varieties and breeding (Bukasov, " The potato, introduction of varieties and breeding.") This consisted of a guide to the description of varieties, by use of a number of characters such as dissection of leaf, which are now in general use. A review was given of the potato varieties

then grown in the Union and certain standard varieties were indicated, these having remained the chief varieties up to the present day. A classification was given of the main varieties of the world.

A study of the whole diversity of the commercial potato varieties of the world disclosed its narrow limits and very limited possibilities ; " potato breeding was stewing in its own juice, using for the introduction of new varieties always the same old parents in innumerable combinations. A cul-de-sac had been reached, with many problems still unsolved, such as phytophthora and virus diseases."

The time was ripe for a new epoch in potato work. An expedition was equipped by the Institute to go to the home of the potato in South America to find new material and new ways of solving the main problems. This expedition, headed by Bukasov and Juzepczuk, carried out during the years 1925-28 an investigation of the Indian areas of America, beginning with Mexico and Guatemala, through Colombia, Peru and Bolivia to Chile and the Argentine Republic. In its extent, and the inclusion of inaccessible mountain regions from which no potato varieties were yet known to science, the expedition was the first in history.

No less than 1,000 samples, representing material of inestimable value, were collected, the investigation of which produced " a revolution in world science " (Bukasov, Lekhnovicz, Kameraz Holmquist). Large numbers of other plants were also collected and yielded equally valuable material (see Bukasov, " Cultivated plants of Mexico, Guatemala and Colombia.").

Of the native potatoes some have proved to be extremely close to the commercial cultivated varieties, others to be markedly different and to belong to distinct species (Juzepczuk and Bukasov, " On the question of the origin of the potato."). Together with unpromising low-yielding species, some not even giving tubers in the U.S.S.R., there occurred others, hitherto unknown, with very high qualities, such as the frost resistant species "akhanuiri," " choke-pitu " and " orko-malko."

The wild species, collected in still greater quantity, were even more varied and interesting—e.g. the " stemless potato," *Solanum acaule*, growing in the mountain regions of Peru and Bolivia to a height of nearly 5,000 m., i.e. nearly to the snow line. Many wild Mexican species such as *S. antipoviczii*, are resistant to phytophthora and the Mexican wild species *S. demissum* is resistant to both this and frost. Several dozen wild species and varieties and 14 cultivated species have been collected.

Those species most nearly related to the European potato were chosen for crossing. In the current year several hundred new hybrid combinations were made and the previous years' hybrids worked out. The seedlings of individual varieties were examined, to decide their merit for breeding and also their genetic constitution.

The species *Solanum andigenum* gave the best results when crossed with the early European potatoes ; the species is moreover highly resistant to frost and the hybrids with European varieties obtained in 1930 proved fertile and gave a large yield of seeds. There will be no difficulty therefore in obtaining an F_2. It will thus be possible to investigate cold resistance both from the genetic and breeding standpoints.

Successful crosses have also been made of the European potato with American forms immune to phytophthora ; it is hoped to grow the F_1 next year.

The importance of these findings is indicated by the numerous requests received for material and the fact that Baur and the Americans have both since taken expeditions to the same countries.

The material was investigated cytologically and later physiologically. The former disclosed the existence in the potato, including the wild species from the Andes of South America, of a polyploid series with somatic chromosome numbers 24, 36, 48, 60 and 72. Cultivated species with 24, 36 and 60 were hereby made known for the first time. This showed the cultivated potato to consist of a number of species and gave the impetus to their physiological study. The cytological study was the only way of rationalizing the work of hybridization. The results were published in three works of Rybin, one of which was reprinted in its entirety in the *Zeitschrift für induktive Abstammungs- und Vererbungslehre.*

The experiments of V. I. Rasumov and A. V. Doroshenko have shown that the photoperiodic reaction of the different species is quite different. A large group of species was discovered which

develop tubers only under short-day conditions and thousands of plants have been kept growing by tubers by reducing the length of day. Rasumov has also studied the after-effect of photoperiodism.

The anatomical investigation has already given very interesting results (Nikovani, Nassonov), and new results have been obtained by investigating the transpiration of different species (Perlova). Much is expected from the study of the period of rest, length of the vegetative period, reaction to virus diseases and to unfavourable ecological conditions.

A preliminary study of the quality of the starch has been made (A. V. Pigulevsky).

In 1932 in the division at Krasnyi Pakhar alone (not counting the Polar Division and the Kalitino Station) over 10,000 inflorescences were hybridized. Methods of mass hybridization were worked out, whereby hundreds of plants could be pollinated. Owing to this and the very favourable conditions of the place chosen near Leningrad (coastal, moist, equable climate and long periods of flowering), even the most difficult interspecific crosses were successful.

The preliminary examination of the hybrids even exceeded expectations. Many of Nesterovitch's hybrids exceed even the standards in yield, as shewn by figures of the White Russian Station, and many of them are resistant to phytophthora.

Vesselovsky has obtained early maturing hybrids with high yield. Many more hybrids are at present awaiting judgment with regard to resistance to frost and phytophthora.

Mention should be made of the method of Voskressenskaja of inducing flowering on shoots from tubers, the buddings made of a number of wild and cultivated species on to nightshades and related plants (Jurkov), the study on the constancy of the yield (Chernjavsky), the vegetative mutations of Asseyeva, the water cultures of Surzhin and a number of more general studies.

Fruit trees.

Many extremely valuable varieties have been isolated from the material brought by the expeditions to the Caucasus and Central Asia :—of apples 15, pears 6, apricots 15, peaches 10, plums 5, institia plums 5, hazel 5, walnut 5, quince 1, pistachio 5, almond 5, fig 5, pomegranate 2, together with a number of olives, chestnuts, willows and other trees, 100 varieties in all. These include varieties resistant to disease and the material is of value not only for breeding, but for immediate introduction and it is being tested and multiplied at a number of stations.

Certain Azerbaijan apples are enumerated as of particular interest, being characterized by especially good keeping quality, large size and excellent colour, and some of which are immune to the Woolly Apple aphis (*Eriosoma lanigerum*, Hausm). Several excellent apples from wild patches in Alma-Ata have been introduced into cultivation.

Pears resistant to drought, for rootstocks, and *Pyrus Boissieriana*, *P. Korshinskyi*, *P. salicifolia*, *P. agrifolia*, *P. heterophylla*, have been found, together with very interesting hitherto unknown local varieties possessed of exceptional keeping qualities, transportability, and others combining excellent fruit quality with low cultural demands.

Several articles on the local and wild apples are in preparation.

The apricots of the Fergana valley contain many excellent varieties hitherto unknown the best of which have been introduced ; they give an excellent dried fruit. Those of North East Fergana and Alma-Ata are very frost resistant and valuable for breeding.

The expeditions to Fergana and Azerbaijan have disclosed an enormous variety of peaches, mostly unnamed ; one very good table variety resembling Elberta, but superior in flavour, occurred ; another outstanding table type from Azerbaijan, of the Elberta type, but with much smaller stone ; and many others with valuable properties.

One of the quinces from the Kubin district was remarkable for the aroma of the jam prepared from it.

Several wild walnuts from Kopet-dhag deserve attention, some of them containing up to 76 per cent oil, as compared with the common 50-66 per cent ; also those from Daghestan and Fergana. Accounts of them have been published. The hazels of Abkhasia are equal to the best European varieties and nearly immune to fungous diseases.

Many valuable pistachios were found, including wild frost-resistant types in Turkmenia, with large kernels (up to 2 cm.), and local cultivated varieties, the largest of which were obviously adventive from Persia ; their quality is of the first rate.

Thirty-one thousand cuttings of the best varieties of fig obtained from expeditions, were planted out at Apsheron in 1931.

A successful method of grafting from trees on to wild stocks has been worked out.

The best clones of export grapes, chiefly Nimrang, have been studied, partly with the object of discovering one with the grapes closer together, to prevent loss during export, also with more uniform size of grape ; forms satisfying both these demands were found and are undergoing multiplication. Many export and drying varieties of extreme merit and hitherto little or not known, have been discovered, including black, red and white varieties, the best of which are enumerated.

Five phylloxera-resistant varieties have been isolated from American material by the Sukhum division of the Institute of Plant Industry and are being planted on a large scale.

Drought resistance has received special attention. One bush species of almond (" Afghan almond ") has proved to be superior to all other fruit trees in drought resistance and this and the pistachio are the only plants which can be cultivated in the huge non-irrigated territories of Central Asia and Transcaucasia. Another very drought resistant plant discovered by the expeditions is *Crataegus azarolus*, with fruits up to 3 cm., very sweet, reminiscent of strawberries ; it is also frost resistant and should be promising for the arid regions of Kazakstan, the Volga basin and South Ukraine ; it should be useful also for preparation of alcohol. For the latter purpose the large fruits of the willow are of great promise ; it has the advantage of growing on salty soils on river banks.

Works on apricots and peaches of the Fergana valley, the hazels of Abkhasia and on pistachios have been published and works on the wild fruit trees of the U.S.S.R. and on fruit cultivation in Azerbaijan and viticulture in Central Asia are in preparation.

Small bush fruits.

The present investigations aim at collecting and studying all existing forms and selecting those best suited to each individual zone and the special demands of different districts and further to improve them by breeding and genetics. The Institute of Plant Industry now possesses 1,000 varietal specimens in addition to 2,000 wild forms and the genetic material and from these the 70 best have been selected for trial in various regions.

Forms of various fruits characterized by greater earliness, productivity, resistance to cold, drought or disease have been found amongst the material, together with such interesting forms as bisexual strawberries and soft-spined *Rubus* species.

The north of the Soviet Union contains a wealth of *Vaccinium*, the Caucasus, Siberia and the Altai mountains of *Rubus* and gooseberries, and the Far East is rich in raspberries, *Actinidia* and edible honeysuckle. By utilizing these forms for introduction and breeding it should be possible to produce types far more successful than the varieties imported from abroad.

The major problem is to extend cultivation northward and into the drought regions. Earliness and resistance to cold and drought are required for this. Crosses are being made between varieties already resistant to cold in the hope of increasing this character.

Further problems under investigation are the inheritance of agronomic characters, the capacity of the different species to hybridize with other nearly related and more distant species, the problem of sex as illustrated by monosexual species such as the garden strawberry, and the artificial production of mutations. Much is expected from interspecific crosses in such genera as *Fragaria* and *Rubus* and the most favourable initial material is being sought. Crossing between different forms of the same species also offers great possibilities.

Medicinal plants.

Since 1926 investigations on the botany, varieties, production of pure lines and regionalization of the aromatic plants in the Soviet Union have been in progress and several expeditions have been organized both within the Union and abroad, to collect the whole world material.

G. K. Kreier and N. A. Adolf, in charge of this group, have isolated varieties of Valerian with yield 3-4 times higher than that of the varieties previously grown.

Camphor trees with higher camphor content have been isolated, 1,300 standard plants having been handed over for multiplication. A new camphor plant, the " camphor basil," has been

found by Nesterenko in the South Coastal Division of the Institute of Plant Industry and is being multiplied.

The best forms of Dalmatian camomile have been selected by the same Division, large quantities being multiplied for insecticidal purposes.

Lobelia containing up to 0.39 per cent of lobelin has been grown in the Leningrad region. Success has almost been attained in the production of non-shedding forms of coriander and cummin.

The best methods of extracting the maximum quantity of opium from the poppy have been studied.

The cultivation of cinchona in Abkhasia and Adjaristan has been attempted.

Fibre plants.

The recent work on flax has consisted in varietal tests of selected varieties. The fact that flax is largely subject to cross-pollination (up to 40 per cent) makes the first step the production of homozygous lines, after which these can be multiplied and compared, both in total yield and in yield of fibre per unit area.

The method of correlation has proved to be of little use in breeding ; the study of the variation of the quantitative characters has shown, however, that certain characters, whose coefficients of variation are low, can be of use in the initial stages of breeding.

" Approbation " has been difficult up to now owing to the absence of varietal characters ; this year various racial characters have been established, such as form of inflorescence and leafiness, and others by which it is possible to carry out " approbation " for seed production.

The study of spontaneous hybridization has been continued in addition to the genetical analysis of various crosses made in previous years.

From crosses of different types of flax various valuable forms have been isolated, including completely non-lodging forms suitable for mechanized harvesting.

An infected plot for testing for *Fusarium* resistance has been made in one year by artificial infection.

This year's work on hemp was limited to sowing out the main types from the world collection, primarily to determine which were capable of ripening in Detskoe Selo and to observe the reaction of southern forms to the greater length of day.

A large group of forms, not only of northern, but also of southern origin, ripened. Odd forms of Italian and Armenian hemps will give seed sufficiently ripe for breeding and for genetic analysis of such characters as plant height and length of vegetative period. The best forms of Italian and southern hemp have been crossed with the early maturing hemps of the north.

Various new fibre plants include *Apocynum venetum*, which is of interest in that it will occupy different areas from those under cotton, ramie, *Abutilon Avicennae* and *Hibiscus cannabinus*.

The Improvement of Breeding Methods.

Breeding Technique.

Hybridization is the only method whereby the necessary combination of characters to make a successful variety under conditions of mechanized harvesting can be effected, the old varieties obtained by selection being on the whole unsuitable. The majority of cereals for instance are too prone either to shed or to lodge. Breeding institutions now have at their disposal the whole of the types existing in the world and moreover the geography of the main agricultural valuable characters is accurately known and thus the breeder can with ease select the material for producing any desired combination of characters by hybridization. Thus, strong straw in wheat is found in the varieties of North West Europe, and also in various other groups of ecologically entirely distinct forms, e.g., the group from Central Asia and Afghanistan, and the spring wheats of India, the selected wheats of Australia and the wheats of the southern part of Outer Mongolia ; also many of the spring *durums* of Palestine, Syria and Transjordania.

Similarly, non-shedding wheats are characteristic of the wheats of India, Afghanistan and the selected wheats of Australia, also of North West Europe and of Khorezm and Afghanistan.

As long as the selection method only was used in breeding *durum* wheat, only an improvement of quality but not of yield was effected and the very productive *durums* of North Africa, Spain, Sardinia and Portugal are of especial interest in this connexion.

On the basis of the tests of the type collections of the best varieties carried out during the last two years at different geographical positions, large numbers of crosses of the Soviet standard hard and soft wheats have been made with the object of improving them in the characters in which they have proved defective. The main Soviet wheats were crossed with special "improvers" selected from the world collection and in this way about 1,000 combinations have been made at the Gandgins station where the world collection is grown. The first generation has already been sown and the material will be carried on to the third generation at Gandgins and then distributed as breeding material to the different regions of the Union.

The crosses having been made mainly with pure line material will also serve for a study of the inheritance of the valuable qualitative and quantitative characters involved.

Variation of quantitative characters.

As a preliminary to the study of the variation of the main characters of practical value, an investigation was made of the components of yield. The chief of these proved to be number of grains per ear or panicle and weight per grain, whilst tillering was much less important.

The variation of these characters was then studied in self-fertilized plants, preparatory to the genetic study of yield. Different crops behave in this respect very differently, the number of grains per panicle in oats being very much more variable than the number per ear in wheat and barley. Size and weight of grain are relatively constant.

Many of these experiments on the variation of quantitative characters in self-fertilized plants indicate the lines which investigation of these plants should take—e.g. that this is always difficult and often impossible under field conditions, on account of their great variability. Studies are being made on other methods as possible substitutes, e.g. vegetative.

The possibility of combining early maturity and high yield in self-pollinated plants by hybridization is also the subject of study ; spring wheat, barley, oats, peas and vetch have been studied and winter wheats have also been included in the crosses. The results show that it is possible to break the normal correlation between earliness and low yield.

The extreme importance of the choice of parents has been made very clear in the course of these experiments. Thus the early oat hybrids derived from northern early parents are more constant in yield than those from southern early ecotypes, whose hybrids are more sensitive to temperature conditions and suffer yield depression in cold winters. Wheat, barley and oats contain two distinct types of early forms, the first, northern forms having low heat requirements and southern ones, often ripening earlier than the former group even in the north, but requiring a considerable amount of warmth and considerably delaying their ripening in cold summers. These differences are clearly inherited and this illustrates the necessity for a thorough knowledge of the whole complex of characters introduced into any cross by the parents.

The breeding department of the Institute of Plant Industry, together with the Polar Division, is studying the methods of creation of early forms for subarctic conditions. A successful choice of suitable oat ecotypes for crossing has already been made and given exceedingly interesting results. Various lines from the cross Ligowo × the Norwegian variety Nidar ripened fully at the Polar Division in the unfavourable summer of last year. This makes possible the production of seed from fodder oats in such regions as the Kola Peninsula, without the necessity of obtaining seed from the south every year.

Purity of Seed and Varietal Material.

The Seed Production Department has studied the influence of different regions of production on the quality of seed ; the determination of seed purity by the American method in comparison with the European method (the former proved distinctly superior and is going to be further tested) ; the microscopic method of distinguishing seeds of lentil vetch from lentil ; methods of distinguishing standard wheat varieties by the coloration of their grains by phenol, by the pigmentation of their leaf sheath, by the pubescence of the leaf ; the characters distinguishing

the red clovers of the eastern U.S.S.R. from the clovers of the west and the characteristic weeds of these clovers have been determined. In this way the origin of a particular sample can be determined ; the eastern clovers commonly have a larger proportion of yellow seeds (30-40 per cent), in the western purple seeds predominate. The characteristic weeds of the eastern clovers are for :—

1. Siberia—*Salsola collina, Artemisia Sieversiana, Thalictrum minus, Agropyrum tenerum* ; also large quantities of *Silene noctiflora, S. dichotoma, Carum Carvi.*
2. Ural region—*Axyris amaranthoides, Artemisia Sieversiana.*
3. Bashkir Republic—*Conium maculatum, Pastinaca sativa.*

There is a marked correlation between region of origin and capacity to retain germinating power in seeds, the continental regions of the U.S.S.R. giving seed much better than that from West Europe and the United States of America.

New Attainments in Genetics and Breeding.

The head of the field division, G. D. Karpechenko, has established the great difference existing in the hereditary characters of geographically widely separated races, so that on crossing these, forms appear in the F_2 and F_3 which exceed the parents in length of ear, height of plant, number of spikelets, etc. No such phenomenon occurs on crossing forms from countries near together. A study of the principles underlying these differences between geographical races may ultimately give the breeder a useful guide to the choice of parental material for a given purpose.

E. I. Barulina has observed similar phenomena in vetches and lentils.

S. A. Shchavinkaja has obtained a tetraploid cabbage by decapitation and regeneration. It is larger and owing to the greater size of the cells it is more juicy. It has been released as a new variety and the method is of great promise also for other crops.

The correlation between crossing capacity of species and their chromosome number has been established by Karpechenko. Thus the tetraploid cabbage crosses easily with Abyssinian mustard, although the diploid will cross only with extreme difficulty ; the same applies to crosses of the new cabbage with various other crucifers. The possibilities of extending the range of hybridization between species by this method are therefore immense. The hybrids of the tetraploid cabbage with mustard are very luxuriant and if constant forms can be obtained they will be of great value for silage.

Hybrids have already been obtained of radish × cabbage × mustard, and of radish × cabbage × rape × turnip.

On the grounds of chromosome morphology *Aegilops persica* has been shown by Senjaninova-Korczagina to be of composite nature, consisting of genoms resembling those of *Ae. caudata* and *Ae. umbellata*, from crosses of which *Ae. persica* has moreover recently been artificially synthesized.

Articles have been published by Karpechenko and Ivanova—on the linkage of genes J and G ; Barulina—inheritance of the ligule in different chromosome wheat species ; Emme—genetical investigation of the oats of the section *Euavena* Greseb. and review of literature on oats ; Ivanova —genetics of barley (in the press) ; Sorokina—*Aegilops* wheat problems (in the press.)

Potato breeding.

The study of the cytology of the cultivated and wild South and Central American species has yielded results of outstanding interest. This, together with systematic studies, has revealed the fact that the cultivated European potatoes constitute only an insignificant part of the extremely polymorphic polyploid group as represented by the wild and semi-wild species of America.

Many of these species are of exceptional interest in possessing resistance to phytophthora and other fungous diseases, frost, drought, degeneration, high productivity and many other characters of agronomic value. The determination of the chromosome numbers and the observation of conjugation between chromosomes of European and American forms has shown the way to new lines of breeding together with the reasons for the failures in the past.

The anatomical method in breeding.

A method of obtaining microphotographic negatives of anatomical objects by projecting from the microscope of specially coloured preparations has been elaborated by M.S. Yakovlev at the Anatomical Laboratory of the Department of Breeding and Genetics. By this method microphotographs are prepared much more quickly, the microphotographs can be transferred directly to photographic paper, without the complicated process of making a positive. No special apparatus is necessary and the method is simple ; a popular bulletin on its use has just been written.

A new graphic method determines the fibre content of the flax stem, by measuring the area of the sector enclosed by two leaf traces ; this is divided into area of the bast fibres × 100 and gives P, the fibre percentage.

New Varieties.

Professor Pissarev has produced the spring wheat Novinka, characterized by early maturity, productivity, large flinty grain of high quality ; it has given an average yield over four years of 11.2 centners per ha. as compared with 8.9 for the local variety—thus an increase of 25.8 per cent—at Luzh. At the North Dvina Breeding Station it gave an average yield over three years of 16.2 centners per ha., the local variety giving 11.9, thus a rise of 36.1 per cent. In the field it gives an average yield of 20 centners and on the best land up to 32.4 It ripens at Luzh in 94 days, the local variety a week later in 101 days. In 1927 the crop from Luzh received a quality mark of 81, the well-known variety Kitchener receiving 80 and Huron 71. In 1932 enough seed to sow 1,000 ha. was produced. The wheat has been described in a bulletin.

Novinka has been crossed with the autumn wheats Grenadier II, Thule II, Bon Fermier and others, from which new spring wheats exceeding Novinka in yield by 15.20 per cent have been obtained.

The variety D.S. 2444 produced by A. V. Pissarev exceeded standard Moscow selected wheat 2311 by 14 per cent in a three-years test, the local wheat being exceeded by 37 per cent. This variety is undergoing multiplication.

Various new hybrid oats have been produced by Professor Pissarev, exceeding the local oats by 15 per cent, the standard varieties by 3.4. per cent and ripening 5-7 days earlier. Some have already been released for testing, others are being multiplied. Their greater earliness is particularly evident in a cold rainy year like 1928.

Pioneer barley is the earliest, ripening in 1930 in 84 days compared with 90 for Cervonets. Pioneer has been released for distribution in northern districts. A two-row malting barley D.S. 865/3 produced by Pissarev exceeded the standard variety Viner in yield and other qualities, including strength of straw, in a three-years test to which it was subjected. The *pallidum* variety D.S. 657/1, also produced by Pissarev, in a five years test excelled the standard variety in yield and size of grain, and was also considerably earlier.

Various pure lines of flax have been selected, and these are superior to the unselected varieties in yield, fibre content and quality. They are being multiplied. A series of articles on flax and breeding methods, etc. has been published and others are in the press. The most suitable methods of cultivation for fibre production have been studied.

Technological Analysis of Plant Varieties.

In the milling and baking laboratory under Chingo-Chingas a method of dividing the laboratory mill into two parts whereby two samples can be milled at a time, with a consequent economy in time and expense, has been devised. As a result three men can now mill 8 specimens a day, in place of 4-5 previously.

An automatic device for indicating the volume of dough during fermentation has been constructed by Chingo-Chingas : at the moment when expansion ceases and a contraction sets in, an electric light and bell give warning signals. This indicates the end of the fermentation process. Different varieties reach this end point at different times and a further device records which of a number of dough samples in the thermostat has reached the end point. The device is now in use in all laboratories in the Union.

A method has also been devised for preserving sections of dough for specimen purposes. A section 3-4 mm. thick is placed between glass plates, one of which is covered with formalin, pressure is applied and the margins are closed up with cotton wool, to which paraffin is applied.

A new method of milling maize has been devised, whereby a milling percentage of 60-70 per cent is obtained, and flour with 0.70-1.67 per cent oil, as compared with up to 3.5 per cent by previous methods. The grain is steamed until the seed coat and embryo are soft, but the centre remains dry ; the seed coat and some of the embryos are removed in a brushing machine and the central portion is then milled in two stages. In the second stage the embryos are flattened out and can then be sieved off from the flour.

The Technical Laboratory for Textile Plants.

A method devised by the laboratory for testing the technical quality of flax and hemp has been adopted in similar laboratories in the Union. The method has been worked out both for fully equipped laboratories and for simple conditions such as are found on the large kolkhoz or the sovkhoz. An average sample of the stem is subjected to hot maceration under prescribed conditions. The pulp is washed, pressed and dried and the fibre extracted. The pulp is removed from the macerating fluid in 4 lots, at intervals of 12 hours, to determine the most suitable length of time for a given variety. Under simple conditions the method of spreading is used in place of maceration. The laboratory has carried out annually about 2,000 such analyses of flaxes and hemps, on which the method of choosing the best varieties has been based ; those varieties which in 2 consecutive years, by the method of "alternative correlation," have proved themselves the most constant in yield of straw and fibre, fibre percentage and general excellence of the plant, are retained, the rest rejected.

On the basis of such observations made on extensive material of the most varied origin, a method of "standardization of flax straw" has been worked out. The length of straw is a varietal character. Thickness, colour and infection by disease are factors influencing the quality of the straw.

Similar work on hemp is now in progress.

Improvement of the Quality of the Products (Biochemistry).

By titration with gelatine a new method of estimating tannins has been found by the Department of Biochemistry. With 1 kg. of gelatine 2,400 analyses can be made and thus there is a tremendous saving of expense. The method is also simpler than the standard method, one worker being able to effect 125 double estimations a month. The method has led to a simplification of the process of extraction for purposes of " approbation " etc.

A thorough review of the tannin plants of the Union has been made and the result is that the Union is in a position not only to supply internal needs, but to export considerable quantities of tanning materials. The possibility has also been demonstrated of producing many other valuable materials from these plants beyond the ones at present extracted. Thus from *Saxifraga crassifolia* hydroquinone ; gallic acid and pyrogallol from *Rhus cotinus* and also a valuable dye phycetin from the roots ; tannins and dye from larch roots and cellulose from the xylem ; and attempts are being made to obtain agaricin and saponin from *Polyporus*, tar and basket fibres from willow twigs and cellulose and paper from the xylem.

A micromethod for determining the alkaloid content of lupins has also been elaborated, whereby one man can make 1,000 estimations a day. By its means an extensive study of the lupins of the world has been made and many alkaloid-free forms have been secured. A micromethod for the quantitative determination of the alkaloids has also been worked out, consisting in precipitating the alkaloids in graduated capillary centrifuging tubes. By this means 0.1 mgm. of alkaloid can be determined. A collective work on the subject has been published.

Another micromethod for the estimation of the fat content of a single seed or a portion thereof consists in treating the dried extract with chromic salts in the presence of a catalyst, after which the determination is made iodometrically. One worker can carry out 400 estimations a month. Breeding for oil content can in this way be enormously facilitated. Two works on the method are in preparation. In 1932 analyses were carried out on $\frac{1}{8}$ and $\frac{1}{6}$ sunflower seeds, the reminder of which were sown to study the inheritance of oil content.

By another micromethod it is possible to determine the coumarin in sweet clover leaves or small seeds—a few crystals of coumarin are extracted on to a slide and give a purple coloration with iodized potassium solutions.

A mechanical method of determining the content of cellular tissue has very much reduced the cost of mass analysis. The method consists of treating the material with a solution of potassium chlorate.

Physiology.

A method has been found in the physiology department of sowing cabbages direct without transplantation. No loss of yield was experienced. Articles on the method have been published.

The development of potato tubers has been accelerated by Maximov by the action of ethylene chlorhydrin before planting. Early varieties are particularly susceptible to treatment and it becomes possible to obtain two generations in one year.

By photo-periodic induction, V. I. Rasumov has also succeeded in accelerating the development of the plant. By lengthening or reducing the length of day in the early stages a change is effected in the vegetative period and yield. The method is applied in breeding, in horticulture and with transplanted field crops. Descriptions of the method have been published.

The amount of water required for irrigation can be reduced by 15-25 per cent by correct adjustment of the time of application.

By the use of a chamber with specially adjusted moisture, temperature and air current a method of determining resistance to drying winds has been evolved. The method, which is complicated in its application, has been described.

By an examination of the form of the growing point two weeks after germination, it has been found possible to distinguish spring from autumn grains.

Vernalization has been effected by the action on cereals of a short period of reduced day followed by ordinary conditions of cultivation, without the necessity for reduced temperature ; it is thought probable that other improvements on the present methods of vernalization will ultimately be effected.

Improvements in the method of direct measurement of frost resistance by the use of frost chambers have been effected. The method, which is in use in many breeding and other institutions, has been described.

The method of wilting has been devised for determination of drought resistance—the method consists simply in observing the capacity of the plant to withstand long periods of wilting without damage. As a preliminary determination the method is applied in several laboratories and has been described.

A simplified method for the determination of frost injury by the electrical conductivity of the expressed sap has been published, and one using the conductivity of the tissue is in preparation. The conductivity increases with the degree of injury.

A correlation has been established between the frost resistance of plants and the photoperiod in which they have developed. Thus the apricot, Fergana rhubarb, walnut, yellow French raspberry, white acacia, etc., become quite frost resistant in the neighbourhood of Leningrad if the length of day is reduced to 14 hours. The application of this method ought to be of use in the introduction of cinchona, citrus trees, sugar cane, etc. to the warmer regions of the Union, where they are at present still subject to damage from cold. The greater length of day during the growing season in the hottest parts of the Union (never less than 16 hours) makes it necessary to consider the effect of reducing the day on all plants where the amount of vegetative tissue is important (textile and forest plants), for in many cases a reduction in length of day brings about an increased vegetative development. Acceleration of the reproduction can also be effected by adjusting the length of day and this greatly facilitates breeding work with perennials. In addition to the direct action of the photoperiod, the so-called after-effect can be made use of in this connexion.

Agrometeorology.

The agroclimatological survey of the U.S.S.R., with charts showing the limits of possible cultivation of the various crops, has been terminated and published. Transcaucasia and the Turksib region formed a special part of this work.

A chart has also been compiled showing the time of occurrence of the main phases of development of the field crops for early, medium and late sowings, and is used in calculating the time of spring and autumn sowings.

B.—ORGANIZATION OF RESEARCH.

The Institute of Plant Industry.

Agricultural research in the U.S.S.R. is entrusted to the care of numerous institutes such as The Institutes of Plant Industry, Animal Industry, Mechanization and Electrification of Agriculture, Soil Science and Manures and the so-called general Institutes of Plant Protection and of Agricultural Meteorology. We are here concerned only with the first of these Institutes.

The Institute of Plant Industry now consists of four autonomous sections :—

(1) Section of Plant Resources and initial Material for Breeding.
(2) Section for Technique of Genetics and Breeding.
(3) Section for Biochemistry and Physiology.
(4) Section for Testing Crops and Varieties.

In 1931 the Soviet Union was divided into 14 zones from the point of view of natural history and economics, in each of which a " Breeding Centre " was organized in 1932 under the direction of the Institute of Plant Industry, for the purpose not only of carrying out breeding work on a number of plants, but also of directing the breeding work of all the Branch Institutes and Zonal Stations in the particular zone.

If a zone is large enough it may also have special breeding stations. Each Breeding Centre has a department of breeding and genetics, and a department of seed production for multiplication of the élite stocks, together with the necessary physiological, chemical and technical laboratories, and where required special laboratories for cytology, anatomy, etc. Special studies of the reaction of the new sorts to external conditions, together with their general characteristics are made.

The Institute of Plant Industry does not concern itself directly with the individual breeding stations or breeding divisions of the special Institutes of which there are 168 in all, but only with the 14 main Breeding Centres. By this system a better connexion is maintained between the individual breeding stations and the Institute of Plant Industry.

Plant Breeding Centres.

(1) The North-Western Plant Breeding Centre covers the north-western and northern parts of European U.S.S.R., and is based upon the Division of Plant Breeding and Genetics of the Institute of Plant Industry, in Detskoe Selo (scientific director Prof. V. E. Pissarev.) Plant breeding is carried on with a wide range of crops, with a view to obtaining earlier varieties in the spring crops and winter-hardy varieties in the winter crops. The humidity of the zone is favourable for the development of fungous diseases ; questions of immunity are therefore of much importance.

(2) The North-Eastern Plant Breeding Centre extends its activities to those parts of European U.S.S.R., and has been developed on the basis of the Plant Breeding Section of the former Vyatka Experiment Station.

(3) The Plant Breeding Centre of the central part of the non-chernozem zone of European U.S.S.R. is organized on the basis of the oldest Plant Breeding Station in the Soviet Union. This centre is concerned with the White Russian Republic, and the Western, Moscow and Ivanov Industrial Regions. The group of crops is similar to those of the first two regions with the addition of buckwheat and *durum* wheat in the southern part of the region, at the Shatilov Station. The new (1932) Mologo-Skeksna Plant Breeding Station for Forage Plants has acquired a valuable collection of *Phleum pratense, Dactylis glomerata, Festuca pratensis* and other grasses from the former Bekasov Plant Breeding Station (Dr. P. T. Zvorykin). Work with grasses is now under the control of the scientific director of the Plant Breeding Centre, Dr. P. I. Lissitzyn, formerly director of the Shatilov Station.

(4) The Upper Volga Plant Breeding Centre is concerned with the eastern part of the southern belt of the Union, with non-chernozem soils, and with the northern part of the forest

steppe zone. The main aim is to breed forms suitable for a continental climate and soils which present a transition from podzol to chernozem.

(5) The Central Chernozem Plant Breeding Centre is concerned with the central part of the forest steppe and the degraded chernozem soils of the European part of the Union. There is a special station for Forage Plant Breeding (" Marussino ").

(6) The Plant Breeding Centre of the Forest Steppe and of Pollessye in the Ukraine is being organized on the basis of a previous station near Belaya Tzerkov. The Institute of Forage Crops in Poltava is primarily concerned with forage plants, including lucerne and *Onobrychis sativa*.

(7) The Plant Breeding Centre of the Steppe at the Ukrainian Institute of Genetics and Plant Breeding, is concerned with the steppes of Ukraine and the Crimean Autonomic Republic.

(8) The Plant Breeding Centre of the Arid Zones is one of the largest in the Soviet Union ; it has arisen on the basis of the former Saratov Station (now the Institute of Grain Industry), and is under the direction of Prof. G. K. Meister. The arid zone embraces the entire Lower Volga Region, the Autonomic Republic of the German Colonists of the Volga, the steppes of the left bank of the Central Volga Region, the northern arid part of North Caucasus and the north-western part of Kazakstan. The chief aim is to obtain drought-resistant forms not liable to shattering and lodging, factors of especial importance in the mechanization of agriculture. Of quite exceptional interest in the research in this centre are the experiments of G. K. Meister with rye-wheat hybrids.

(9) The West Siberian Plant Breeding Centre at Omsk is concerned with West Siberia, the Trans-Ural part of the Ural Region and north-west Kazakstan. The chief crops are hard and soft wheats (up to 75 per cent of the acreage). Then follow pulses (pea, lentil, bean) and fodder legumes (*Melilotus, Onobrychis* and *Medicago* spp.).

(10) The Northern Caucasus Plant Breeding Centre is in a zone where the moisture conditions are partly satisfactory, partly unstable. The Plant Breeding Division of the Transcaucasian Institute for Cotton Cultivation in Azerbaijan, near Gandgins, breeds cotton, with wheat and barley, autumn sown peas and vetches, lucerne and *Trifolium resupinatum*.

(11) The Central Plant Breeding Station of Georgia has completed an extensive study of the cultivated plants of Transcaucasia and is now devoting attention to the breeding of cereals, pulses and forage crops. A Zonal Station is primarily interested in soya bean research. Sub-tropical plants are studied along the Black Sea Coast and tea at Ozurgety in Western Georgia. In Continental Armenia the programme at Leninakan includes cereal breeding, and forage plants in the mountain and alpine pastures. Other crops in Georgia include the grape vine and tobacco.

(12) The Central Asiatic Plant Breeding Centre covers the Central Asia Republics. Crops include cotton, wheat, and legumes, of which the most important is lucerne.

(13) The East Siberian Plant Breeding Centre is concerned with the immense territory of Eastern Siberia, with the Buryat, Mongolian and Yakutian Autonomic Republics. Crops studied include flax, wheat and potato.

(14) The Plant Breeding Centre of the Far East is based on the Experiment Station of Nikolsk-Ussurijsk. The principal crops of the zone are spring wheat, sorghum, rice, technical plants, sugar beet, sunflower, soya bean and sesame.

C.—THE SECOND FIVE YEAR PLAN (1933-37).

INTRODUCTORY ADDRESS.

The last 10 years have brought about a fundamental change in the notions on the main branches of genetics. Artificial mutations have been produced, crosses have been made between species and genera, thus bridging the gap between them, creating not only new forms but transgressing the limits of the existing species. The idea of the Linnean species itself has undergone a fundamental change as a result of the enormous new material contributing to the knowledge of variation. The very ideas on the hereditary structure of organisms have changed.

The 19th century being characterized by the development of descriptive biology, the 20th will be styled the century of the experimental study of the evolutionary process, the control of the process of the origin of forms.

Genetics, the science of the inheritance and origin of organisms, is impinging more and more on the problems of botanists and zoologists, and through breeding also on the realms of stock and seed production. Breeders are playing an ever-increasing part in the solution of genetic problems and the colossal possibilities of the new socialistic agricultural developments have given an equally important stimulus to genetic research.

Scientific work in capitalistic countries is unplanned. The big genetic institutes of England and the United States of America are dependent on chance private funds and the recent crisis is bringing the workers to an impasse. In view of the overproduction in the majority of crops, the improvement of quality, at which breeding has been aimed, has been robbed of all sense. Many workers, including geneticists and breeders, have applied for posts in the U.S.S.R.

The collectivation of the peasant holdings in the U.S.S.R. on the other hand has opened up horizons for the breeder of which it is still not possible to form the slightest idea ; inferior crops are to be replaced by superior and more valuable ones, old varieties by more productive ones, cultivation is to be extended towards the east, northwards, yields are to be raised, Soviet workers are presented with the problem of the improvement, production and introduction of new forms of plants and new races of animals.

The present forms and races are not equal to the demands of large-scale specialized socialistic methods, based on the maximum mechanization and " chemization." Even of the main field crops the ideal varieties are not yet available, even the best varieties of wheat display certain serious defects. There is an insufficiency of cold resistant forms and of forms resistant to drought.

The completion of the first Five Year Plan in four years demonstrates the mighty possibilities of socialistic agriculture and the collective principle. In the last two years alone (1930-1931) the area sown was increased by 18 million ha., the area under cotton increased to three times the pre-war figure in the course of four years and cotton has become established, contrary to expectations three or four years ago, in new regions such as South Ukraine and North Caucasus. All doubt as to whether the cultivation of high quality Egyptian cotton in the Union is practicable has been dispelled in the last two years, over 52 thousand ha. being now in cultivation in Central Asia and the whole requirements of high-quality cotton will be supplied by the plantations under this species in the second Five Year Plan.

The main points of the plan are as follows :—

(1) Transference in all the moist regions of the Union to intensive agriculture based on the use of mineral manures.

(2) The creation of new productive agricultural tracts in the east, particularly Siberia and the Far East.

(3) The creation on the basis of irrigation of special wheat belts in the Volga Basin with an annual production of up to 50 million centners.

(4) The extension of the area under crops from 137 million hectares (1932) to 170 million in 1937, that is an increase in production of not less than 60-70 per cent.

(5) A general raising of the quantity and quality of the yield of the main crops.

The old inferior varieties of grain crops will be replaced very early in the second Five Year Plan by improved selected varieties and breeding for drought resistance will be extended. There will be great increases in the production of maize, leguminous crops and sugar (including sugar from maize, chicory, &c.). The areas under tea, citrus, rubber plants have been raised from inconsiderable dimensions to hundreds of thousands of hectares, in 1937 it is planned to have 4 million ha. under fruit and 200 thousand to a million under vines alone, and vegetables and cucurbits present special new problems of their own. Methods of variety testing and seed control, and of production of new varieties of fruit trees, are of first rate importance. Measures have been taken on a large scale to multiply the existing high quality varieties and to produce new ones.

The state seed control presents new problems to the breeder, whose entire work must be reorganized, as must also the work of multiplication and seed production.

The extension of cultivation into new areas and the introduction of new crops are intimately connected with the production of new varieties, and thus with breeding work. The extension of wheat towards the east cannot be effected without considerable alteration in the present varieties.

The present article deals with the genetical investigations which are the theoretical basis of practical breeding. Breeding as a science is constituted from the synthesis of the data of many branches of investigation, with the object of producing the varieties necessary for socialistic agriculture. Genetics is one of the most fundamental parts of breeding, but does not exhaust it. The breeder requires the help of physiologists, systematists, biochemists, phytopathologists, technologists. The methods of breeding themselves apply to the individual plants and constitute a large and hitherto little investigated branch of knowledge. Nevertheless, the main achievements of breeding lie in the knowledge and control of the hereditary characters of plants and animals. This is the main contribution of genetics to breeding work.

Problems of Special Genetics.

Discussing the individual problems of the Five Year Plan in the "Division of Special Genetics," the genetics of individual crops comes first, since the demands of modern industry require that we shall first of all devote our attention to the investigation of the inheritance of the valuable agricultural characters.

Breeding has in the past been detached from genetics. The enormous material used by the breeder has as a rule not been genetically worked out and has become completely lost in the archives. Very often no written data are available on the production of varieties, as in the well-known case of Burbank's breeding work, the production of noted wheats such as Marquis and innumerable other similar cases.

Breeders not infrequently even deliberately refused to work out the genetics of their material, especially in the western European countries and also Canada and the United States, where breeding is mainly in the hands of the seed firms.

The aim is to put an end to this gulf between genetics and breeding, to rationalize the work of the breeders from a genetic point of view and to link up the work of the geneticists with breeding. In this way both parties will gain ; this will be one of the greatest achievements of future work. The works of Nilsson-Ehle and Baur can be quoted as examples of the harmonious union of first class genetic work with the greatest achievements in practical breeding.

Such an organized linking up of genetics and breeding reveals tremendous new possibilities for the solution of practical problems ; the theory simplifies and gives sense to practical breeding, and at the same time receives new impulse to its own development.

Problems of initial material for breeding and genetical investigations.

The time has now come when the investigator should begin to attack systematically the question of the initial material for breeding and genetic investigations. Up to now the choice of material, especially for genetic work, has been entirely at random—this or that material was easily available, certain varieties happened to be present. Genetic investigations on the individual crops are strikingly fragmentary with regard to the varieties embraced and usually entirely ignore the actual composition of the Linnean species examined. The geneticist in the past has not thought of giving the characteristics of the whole of the individual species on the basis of a

fundamental systematic-geographical investigation of the varietal diversity. When the geneticist has attempted to do this on the basis of the odd fragments examined, he has naturally come to entirely false conclusions. Fruwirth's manual, which gives a summary of the investigations on the inheritance of the individual characters of cultivated plants, makes generalizations which in the light of the new differential knowledge of the varietal composition of the species appear quite unconvincing. They are usually based on chance fragments—varieties picked at random from odd species. The tremendous work carried out on the collection and study of initial varietal material of the main cultivated plants is undoubtedly a great achievement. Even in the main old crops which were apparently well known, novelties have been discovered of which the investigator would not even have dreamt ten years ago. Even for such plants as wheat, numbers of varieties and varietal characters, many times greater than those formerly known to science, together with a series of new botanical species, have been discovered. Our ideas on such plants as the potato have been entirely revised, the whole work of breeding and genetics having been formerly based on one Linnean species (*Solanum tuberosum*), whereas the expedition to South America disclosed the existence amongst the cultivated potatoes at its original home of no less than thirteen well-defined Linnean species, many of which are of great practical interest. These species differ from one another in chromosome number, morphological and physiological characters and area of distribution. They contain species and forms extremely resistant to diseases and frost. The potatoes formerly known to geneticists and breeders were only fragments of one species, collected at random by the first travellers, and on these the whole of the breeding and genetic work of the 19th and beginning of the 20th century has been based.

Plants such as oats, barley, cotton, flax, legumes, cucurbits, vegetables (tomatoes, radish, turnip, cabbage, carrot, etc.), fruit trees (especially the wild and cultivated varieties of Central Asia and the Caucasus) have been presented in an entirely new form and our ideas on the cultivated plants have, as a result of systematic study on a world scale, been fundamentally changed ; the species are shewn to the investigator in a completely new aspect. The examples of potato, wheat and many other plants shew what possibilities remain in breeding and genetical work.

The Soviet investigations of recent years have given a new botanical-geographical foundation to the study of cultivated plants and new methods of investigating the composition of the Linnean species. This fact has great significance, both from the point of view of principle and practice and should serve as the foundation for all breeding and genetic work of the next and later Five Year Plans. It radically changes the very approach to breeding work. In order to approach the species genetically and attack the problems of evaluation and the origin of forms in the light of the new knowledge, we must start from the species as entire complexes or systems and try, as far as possible, to exhaust the variety of the present composition of the species.

In a number of cultivated plants which have been subjected to systematic-geographical investigation, there have been revealed actual strata of entirely unknown species and of varieties with a large number of new and rare characters of practical value, unknown to the breeders and geneticists of the past. These achievements must be used in the work of future years on the study of the species of cultivated plants.

We will pass now to a review of the main agricultural characters which have in the past remained outside the sphere of the geneticist and to a large extent also of the breeder ; firstly those characters which are common to all the main crops with which the Soviet breeders are working.

Immunity to diseases.

Immunity to disease affords a good example of the extent and complication of the research envisaged. Some crops suffer from possibly a dozen different diseases, fungous, bacterial, insect etc. Only those to which the plants shew varietal differences will be dealt with here.

In addition to the tremendous number of diseases, these themselves have in recent years been found to display the same varietal differentiation as the crops. The study of physiological forms is still only in its infancy. It has been carried out mainly in America and principally on crops introduced from the Old World. We can imagine the wealth of physiological forms of rust, smut, etc., of wheat, barley, oats, flax, etc., which will be discovered when we

begin to study them in the vicinity of the primary areas of origin of forms of the cultivated plants, in which areas it is common to observe a corresponding variety of the parasites. Moreover, new virulent forms of the parasite have recently been produced by hybridization. These facts greatly complicate the breeding work. The difficulties must however be overcome.

In the next Five Year Plan it seems advisable, in addition to the study of the biology, ecology and differentiation of the parasites, to concentrate attention on the so-called group immunity. Certain varieties have definitely proved immune to a large group of different physiological races and even to a number of different species of parasites. This circumstance simplifies breeding and genetic work and should be the centre of future attention.

World science still knows very little as to the inheritance of immunity ; the knowledge is fragmentary. This must also receive great attention.

In view of the enormity of the variety of cultivated plants and of their parasites, the creation of immune varieties of the main crops can only be achieved by collective study, by extensive breeding work on the part of the breeding centres and various branches of the institutes with their net of zonal stations for individual crops. The general institutes, beginning with the Academy of Sciences, will concern themselves with problems of method, which in the near future are to be of primary importance.

Drought resistance, winterhardiness, cold resistance.

Characteristic for these qualities are the great varietal differences displayed by the crops and also the difficulty of their experimental investigation. Genetics has avoided and still avoids this section. Drought and cold resistance themselves are very complicated phenomena, for different kinds of drought exist, also there are differences in the behaviour of the plant depending on age, so-called hardening, etc. ; thus *Triticum durum*, for instance, is drought resistant during the period of ripening, but in the initial growth period is usually not resistant.

The investigation of these characters is complicated by the variation of climatic conditions and the greater severity compared with the United States and western Europe, whose results therefore are of little value.

Both for the genetical and breeding study of these questions a systematic utilization of the world collection of the whole ecological varietal range, so as to establish the limits for each species, is necessary. To find the extreme variants which are of special interest for the solution of these problems, the full range of varietal difference must be established by a study of the world collection. Unfortunately this has not been done in physiology and much less so in breeding, which sciences have restricted themselves to a narrow circle of random varieties. Even for the most important crops there exist no definite physiological data on the varietal amplitude of the species with regard to drought and winterhardiness. A study of world geography and ecology of cultivated plants, convinces us of the presence of great differences in these respects, but they have so far been investigated neither by the breeder, physiologist nor geneticist.

The extensive use of crosses between geographical races will probably extend the limit of varietal variation in these characters.

It is obvious that the geneticist and breeder must work in co-operation with the physiologist, just as for immunity they must work with the phytopathologist.

For these studies new experimental equipment and a new plan of the whole work are necessary. Part of the work must be transferred to the field, to the different ecological conditions existing in the Union. In the new problems encountered in this sphere little assistance is gained from world science. In developing this work it should be kept in mind that the characters required are apparently, at least for some groups of plants, recessive. It is difficult to say how far this is generally the case, but it must at least be borne in mind in applying the methods of inbreeding and hybridization.

Vegetative period.

Agricultural conditions in the Soviet Union, the new tempo and new organization, the variety of conditions and the increased number of crops, have introduced new problems for the breeder.

In the Soviet Union the vegetative period is of fundamental importance on account of the efforts to extend cultivation to the north and to the east and the necessity for shortening the

vegetative period in the south, so as to avoid the drought. It is therefore necessary to cultivate mainly varieties with short vegetative period. Even in the North Caucasus, with an apparently long vegetative period, it is necessary to cultivate early varieties of maize, on account of the intense heat experienced, especially in the steppe regions, in the summer ; only varieties which flower before the drought are therefore successful. Similarly with fruit trees, it is necessary to reckon with the frosts which frequently occur during the flowering period and here again to aim at varieties which flower after the frosts are over.

The theory of the vegetative period is undergoing a critical period. Perhaps no other branch of physiology is witnessing such advances. The work of T. D. Lyssenko is in this respect outstanding ; the comparatively simple method of vernalization, the possibility of its wide industrial application, are revealing new horizons. The investigation of the world collection of wheat and other crops under the action of vernalization has this year disclosed facts of exceptional significance. The world collection of wheat under the simple treatment of vernalization was entirely transformed ; in the south east, where the breeder had never seen *Triticum turgidum* in the field on account of its dying out if sown in autumn and failure to ear if sown in spring, it proved possible by vernalization to grow perfectly normal large-eared specimens. Winter varieties are converted into spring varieties, late into early. Everything out of the world collection that was previously cut off from these regions has now become a reality. Certain geographical groups of the world collection often displayed a definite type of behaviour when vernalized and this will probably be characteristic for different crops. It is already a confirmed fact that vernalization is the greatest achievement of breeding since it has made available the whole world diversity of varieties, which up to now has been impossible owing to the unsuitable vegetative period and insufficient cold resistance of the southern forms. We can already say that the intensive tasks of irrigation of the Volga Basin, by applying the method of vernalization, will make it possible to utilize the highest yielding world varieties, including even *Triticum turgidum*. It is possible that even by merely examining the world collection after vernalization, we shall be able to select new valuable forms capable of being directly introduced into the various regions and excelling the varieties at present cultivated. The possibility of using the world collection for hybridization has also been immensely extended.

The discoveries in the realm of photoperiodism have introduced a new era in controlling the vegetative period. By reducing the length of day it has been possible to induce tropical cottons to flower and bear fruit in Soviet conditions and similar results have been obtained with other crops.

Geneticists and breeders are awaiting the investigation by the physiologist of the special physiology of individual crops, varietal physiology, physiological systematics of the varieties. This should both enrich and simplify breeding work.

The results of the last few years have shewn the necessity for an entirely new approach to the genetics of the vegetative period. There is no doubt that by applying vernalization, photoperiodism and other factors we shall succeed in shedding new light on the segregation occurring in crosses of varieties of different vegetative period.

The work is only just beginning. We must have an extensive collective study by physiologists, biochemists, breeders and geneticists, working on different crops, on a definite plan, with the world collection as a foundation in order to learn actually to control the phases in the growth of the plant and the characters associated with them. The vegetative period is of major importance in breeding since many characters are associated with it, such as the chemical nature of the plant, its reaction to diseases and often its general form. It is difficult to form the least idea of the practical possibilities resulting from the control of the vegetative period.

Chemical composition of plants.

In spite of the fact that many plants are cultivated entirely for the sake of their chemical constituents, such as sugar beet, tobacco, various oil plants, the genetics of these characters is very little understood. The work of the Academy of Sciences has indicated that serious revision is necessary in our ideas of " polymeric factors."

The time has come for a serious genetic study of the chemistry of the plants and on the

improvement of their chemical composition. The French investigators for instance have found wild forms of sugar beet excelling the cultivated forms in sugar content. Such forms as these should be used in crossing with cultivated forms.

A start has been made in the study of the genetics and chemistry of pigments by Onslow and of aromatic compounds by Armstrong.

The experiments made in the last few years by the Institute of Plant Industry have demonstrated the wide chemical differences which exist within different species and groups of plants. Certain compounds such as alkaloids, essential oils, etc., are subject to definite laws as to the occurrence of the varietal and specific differences. It will certainly be possible by crossing different species and varieties to create new and valuable combinations. Genetics and chemistry will have to combine to achieve this. Within certain genera, species and races there have been found definite cycles of chemical compounds. Appropriate crossing should make it possible to produce desired types artificially.

Technological differences between varieties.

The scraps of knowledge so far available on the inheritance of milling and baking quality in wheat are altogether inadequate for a thorough understanding of the inheritance of varietal differences and with regard to the main technological characters, even lint length in fibre plants, the geneticist is in almost complete ignorance.

An examination of the literature of the whole world on cotton genetics shows the extremely scanty nature of the information available, which is entirely inadequate for the requirements, especially in respect of such an important crop as cotton. Even for this crop, where each millimetre in the length of lint represents millions of dollars, there are no adequate data on the genetics of lint length. The genetics of size of boll, length of lint, quality of lint has been almost entirely neglected in world science.

The data collected in the classical work of Tine Tammes on flax genetics are similarly entirely inadequate, in that they fail to take into account the colossal diversity of varieties and geographical groups which the flax plant represents.

The mechanization of agriculture in the U.S.S.R. is presenting the breeder and also the geneticist with a number of new problems in every single crop without exception. Shedding and lodging in cereals, which prevent the use of the best harvesting machines, must be combated and types created which possess a disposition of the fruits, inflorescences, &c. more suited to mechanized harvesting.

Varietal differences with regard to substrate.

New problems for the breeder and geneticist are also presented by the growing use of chemicals. Recent investigations in Denmark, Sweden and Germany have demonstrated the existence of great varietal differences in cereals in respect of the utilization of mineral manures, and new varieties have been selected which are characterized by a more productive utilization of these manures than the former varieties, from which they are often externally indistinguishable. Differences in productivity amounting to 15-20 per cent have been observed.

Quantitative Characters.

The genetics of quantitative characters will have to receive great attention in coming years. In the past they have been neglected on account of their complicated nature and the existence of so many intermediate forms and even for plants whose genetics are best known no data on the inheritance of quantitative characters exist, as is shown by examinations of collective works on special genetics such as those composed by Philiptschenko, Matsuura, and Bibliographia Genetica.

The study of the inheritance of quantitative characters requires vast theoretical and methodological work as is shown even by the fragments of knowledge already obtained by the old methods; the interaction of the genes and the phenomenon of pleiotropy are very evident where quantitative characters are concerned.

Recent studies of the Institute of Plant Industry on the degree of differences in quantitative

characters in many cultivated plants have demonstrated the complexity of these characters and their tendency to be inherited in groups. A more fundamental study will not improbably effect a radical revision of the simple Mendelian representation.

In addition to the above agricultural characters there exists an enormous number of specific characters associated with each individual plant which must also be studied. For instance there is in wheat the inheritance of awns, in barley the character of grain, in connexion with the requirements of the brewing industry, etc. In organizing the work it is necessary of course always to decide upon the relative importance of the different problems. At the present time practical breeding work is in progress in the Union with no less than 200 cultivated plants. Fundamental breeding work is in progress with no less than 100.

The above will give an ample illustration of the enormity and complexity and the scale of the work of the next Five Year Plan.

The work will be distributed to general and branch institutes and breeding stations. The general institutes will have to concentrate their attention on working out the problems of method and the theory of inheritance of the individual characters of most importance, and for this the object itself is of secondary interest. The branch institutes, breeding centres and breeding stations are primarily concerned with the objects themselves. A direct contact between the institutes and breeding stations and the industry will ensure that the work is carried out in such a way as to produce the required varieties. This is the main concern of the branch institutes and divisional stations and of the breeding centres and breeding stations. The general institutes during their work on questions of method may create valuable varieties ; this is desirable but not obligatory.

Problems of General Genetics.

The characteristic feature of modern genetics is that the solution of the main theoretical problems is at the same time leading to the solution of the most urgent demands of socialistic industry.

The problem of distant hybridization.

This is one of the first tasks of the second Five Year Plan, to work out the possibility of application of hybridization of different species and genera. It represents one of the most attractive problems of the breeder and agronomist and the combination by this means of the most interesting characters into one variety is one of the ideals of practical breeding. For instance, in wheat the production of immune varieties and forms resistant to drought rests more than anything on the production of distant hybrids, since the group of species with low chromosome number, genetically distinct from the common wheats, is characterized by a complex group immunity and the existence of drought resistant forms.

The same is true of cultivated oats ; varieties resistant to bunt, rust and drought can only be obtained by interspecific hybridization. Such species as *Avena strigosa* and *A. byzantina* are characterized by group immunity to bunt, rust and drought.

Similarly one of the most interesting problems in vine breeding consists in combining the resistance to phylloxera and other diseases of the American species with the high quality and yield of the European vine.

Many problems of fruit production are also connected with interspecific hybridization. I. V. Michurin was the first to hybridize the eastern Asiastic wild cold-resistant species of vine, pear and apple with our cultivated susceptible varieties.

Again in cotton, if the lint of the Egyptian cotton could be combined with the earliness of Upland or Central Asiatic native cottons, one of the biggest problems of the cotton industry would be solved.

If hybrids between *Scorzonera Tau-saghiz* could be crossed with the cultivated *Scorzonera* with thickened stem, at the same time transferring the high rubber content of the first species, this would constitute a most decided change in the genotype which would very greatly facilitate the solution of the problem of natural rubber.

Up till recently interspecific crossing has been one of the most difficult branches of genetics and the breeder has been chary of applying it. Scepticism has often been expressed as to its

value for breeding purposes, especially in plants reproduced by seed. The method has not been applied by institutions such as Svalöf and Vilmorin. The greatest cotton breeders consider that crosses between Upland and Egyptian cottons offer no practical hope on account of their excessive segregation, sterility and disharmony. Assertions are still found in the scientific cotton literature to the effect that such crosses have no practical importance.

Results of the last few years lead us to be much more optimistic. Soviet breeders and geneticists especially have made many positive contributions, e.g. the Institute of Plant Industry, the Institute of Grain Industry at Saratov, the Institute of Genetics and Breeding at Odessa, the Central Asiatic Institute of Cotton Industry and I. V. Michurin have discovered new and extensive possibilities. It has been shown that the possibility of crossing species is greater than was formerly thought. A number of species, which in the classical literature were regarded as incapable of crossing, have been crossed. At the Tashkent Institute hybrids of Upland and Egyptian cotton have been used in practice and hybrids of the second and later generations have moreover been obtained between New and Old World cottons.

The duplication of the chromosomes in sterile hybrids leading to fertility, illustrated by Karpechenko's hybrid between cabbage and radish, has now been observed in a number of plants.

Scientists are now well on the way to the conquest of the sterility characteristic of distant hybrids. D. Kostoff and S. A. Eghis have discovered the possibility of obtaining fertile hybrids by crossing three species of tobacco and other plants. Kostoff's method of triple crossing, using species differing in their multiples of the basic chromosome number, is worthy of great attention. For instance, sterile hybrids of wheat species differing in chromosome number when crossed with a species which completes the homologous chromosome set, may possibly prove fertile ; thus *Triticum monococcum* (7 chromosomes) crossed with *T. durum* (14 chromosomes) gives sterile hybrids. By crossing this hybrid with 21 chromosome *vulgare* wheat, Kostoff obtained fertile hybrids. If a more extensive study confirms these facts new and very wide possibilities will be presented to the breeder and geneticist ; thus by combining in this way the characters normally separated over three species entirely new forms may be obtained ; for instance the immunity of einkorn might even be transferred to the soft wheats.

Eghis, Kostoff and Clausen have shown experimentally that common tobacco can be produced synthetically by crossing different species. The same has been shown this year in the Institute of Plant Industry by O. N. Sorokina by crossing *Aegilops triuncialis* with *Triticum diccocoides*, whereby synthetic Persian wheat, *T. persicum*, has been produced.

As a result of persistent work on crossing species of wheat with species of *Aegilops* promising results in the production of polyploid forms are beginning to be obtained.

The demonstration by Karpechenko of the possibility of increasing the crossing capacity by artificial polyploidy is particularly significant. The tetraploid cabbage produced by Jorgensen's method proved capable of crossing with much greater ease than the ordinary cabbage with various species such as for instance the Abyssinian mustard, *Brassica carinata*.

The physiologists are expected to assist in the solution of the problem of sterility. In certain spheres it is becoming more and more difficult to separate genetical from physiological work ; for instance in artificial mutations it is actually already time for the geneticist to make way for the physiologist.

The scale on which the work is carried out is of extreme importance. For instance the hybridization of Upland with Egyptian cottons begun by Zaitzev and continued by Vysotskii showed that with a large number of generations on a large scale there do appear valuable forms combining the characters of the two species. This is to be expected theoretically, although up to the present time the production of useful forms from such crosses has been regarded as improbable.

The work of the Northern Fruit Institute, continuing the work of Michurin, has shown that by wide hybridization on a large scale valuable forms combining the characters of the parents can be produced. The combination of the Siberian and Far Eastern wild fruit trees with cultivated forms, started with success by Michurin and Kaščenko, is worthy of further development on the basis of modern genetical knowledge. The enormous resources of wild species of fruit

trees in the forest of the Caucasus, Central Asia and the Far East ought to be used in the improvement of our cultivated forms. The mountains of Turkmenia, the Tajik Republics and Transcaucasia contain valuable species of wild almond and wild pear distinguished by resistance to drought and immunity to diseases.

During the next Five Year Plan the wild species of potato will be used for improving the quality of our common varieties and introducing immunity to various diseases and to frost. Wild forms have been found in the mountains of Peru and Bolivia which tolerate -10°C without loss of leaves.

The first requirement in making use of distant crosses has been shown to be to carry out the work on a suitable scale and to enlist the services of the cytologist, without whom no serious work on distant hybridization can at the present time be considered.

Crossing Geographical races.

This method has not yet received sufficient attention either from the geneticist or the breeder ; a great many new combinations of characters can however be obtained by crossing distant forms belonging to the same or nearly related species which give no sterility on crossing. Such crosses, on account of the number of genes in which the parents differ, are an intermediate stage between interspecific crosses and crosses between nearly related varieties such as are recommended by Svalof and Vilmorin, who definitely avoid crosses of any but the most closely related forms on account of the excessive segregation which results and the amount of work thereby entailed. The continental climate of the Soviet Union, the variety of its conditions, the unsatisfactory nature of the existing varieties in respect of drought, cold and disease resistance make the alternative method as applied by Baur and the Merton Institute in England, making use of widely different races, definitely more promising. One of the only hopes of combating the excessive losses due to frost and drought seems to lie in crossing forms widely differing in reaction to these two factors.

Such crosses obviate the difficulties of sterility and disharmony invariably encountered in interspecific crosses. The enormous new varietal material now available makes it possible to put the whole problem on a new footing. The extreme limits of the species must be chosen as parents, and also the corresponding wild ancestors of the cultivated plants. The crosses are used as a means of evoking the full amplitude of natural variation and the potentialities for form development of the entire species.

The geographic-systematist, together with the geneticist, will be able in the next few years to determine the most appropriate combination of geographical races for the improvement of existing varieties.

The first experiments on these lines are already showing great promise. By crossing different geographical races of barley new qualities, such as smooth awns, have been discovered. In these experiments, Karpechenko has observed very marked deviations in length of ear, size of grain, etc. and altogether the most interesting and marked advances without loss of productivity are evidently to be obtained by crossing geographical races.

Many analogous facts could be quoted. For the improvement of the *durum* wheats the awnless Abyssinian *durums*, the large-grained Syrian *durums* and the early *durums* from Cyprus and the mountains of Arabia must be used. The use of the tremendous variety of Central Asiatic native cottons recently found in Persia, West China and Afghanistan on similar lines ought to make it possible to create valuable varieties of this species of cotton, for there do exist, in the countries neighbouring the U S.S.R., forms of this cotton possessed of high quality and yield and quite different from those at present found in the Soviet Union, which it has been found necessary to replace by Uplands. The case with other crops is the same and on the basis of the world collections now available tremendous advances in this direction are expected in the next few years.

Heterosis.

The hybrid vigour of first generation hybrids has been extensively used in Japan, for instance in silkworms, but in plants has received less application. There is little doubt that the phenomenon deserves much wider application also in plants, especially in forest and fruit trees, tomatoes, egg plant, maize (for culinary use) and possibly also cotton. Study should be made

not only of the genetic aspect of the phenomenon, but also the physiological, biochemical and biophysical.

Phenomena of Polyploidy.

Jorgensen's method of producing polyploids should receive wide attention in the near future, since polyploidy is now known to be frequently associated with valuable qualities such as increased vigour of growth, greater adaptation to extreme northern climate or conditions of extreme drought (Hagerup). Many of the large-flowered ornamental plants are polyploids and a number of other characters, including immunity, are associated with polyploidy.

It is expected of the physiologists that they will provide a method of vegetative reproduction and of increasing the production of shoots from the callus, for preliminary experiments at the Institute of Plant Industry have shown that considerable improvements can be brought about in this direction. In the next Five Year Plan particular attention will be devoted to the method of production of polyploid forms (amphidiploids and haploids), the study of the quantitative and qualitative differences in polyploids, the inheritance of characters in polyploids and the elaboration of a method of producing homozygous plants by chromosome duplication in haploid, diploid and other forms.

The Problem of Artificial Mutations.

A short time ago the practical breeder had no concern with mutations beyond certain vegetative mutations in citrus fruits and potatoes and only the artificial production of mutations achieved in the last few years have put the question on a new footing. These achievements notwithstanding, a great deal of work is still necessary on the methods, on the factors inducing mutations and on their nature. The physiology of the mutational process is almost untouched and no experimental study has been made on the relation of mutation with hybridization or with inbreeding.

We are in need of a comparative study on the genetics of mutation in different organisms, on the role of the genotype itself in mutation and on the type of mutations and their correspondence under the action of different agencies. The role of geographical factors in natural mutations has not been studied at all.

The method of producing mutations must be further worked out and it is especially desirable to have further information on how far artificial mutations are undesirable or uninteresting from a practical standpoint. The number of plants studied should thus be enlarged. Suitable plant material possessed of rapid growth, a great variety of forms, abundant reproduction and suitable for cytological analysis should be sought. The rich flora of Central Asia and Caucasus ought to offer such material. The general institutes should undertake a study of the dynamics of mutation by the application of the cytological method and special attention should be directed to physiological as opposed to morphological mutations. Altogether, the problem of artificial mutations is one of primary importance and affords an admirable illustration of the way in which breeding stands in need of theory.

Permanent Modifications.

The nature, types and factors producing the so-called "Dauermodifikationen" must receive adequate study. The conversion of these into mutations is of great theoretical interest, as are their influence on the mutational process, their duration and the speed at which they disappear. They can be studied by sexual, asexual and parthenogenetic reproduction. Why are they suddenly cut short by sexual reproduction?

These phenomena, although mainly studied in animals, are no less real and interesting in plants, though of a somewhat different nature.

Plant Chimaeras.

Plant chimaeras have up to now been far removed from practical agronomy, though offering intersting phenomena. One of the most attractive problems of the near future will be the attempt to produce immune forms by covering a susceptible form with a chimerical layer of

another immune form or species. This is especially interesting in such plants as potato, citrus, vine, apple and other fruits. This question is linked up with that of vegetative mutations, which must be studied in the first place in potatoes and citrus fruits.

The Problem of the Inheritance of Quantitative Characters.

The majority of agronomic characters are quantitative and have been discussed in the special section. Great advances in the understanding of the inheritance of these characters are expected from the genetic institutes, particularly in methods of investigating the variation and inheritance of quantitative characters in self and cross-fertilized plants. A more systematic study of the influence of external conditions on the variation of quantitative characters and on their variation in different species and genera is desirable. Genetics must tackle the problem of actual plant growth.

The problem of polymeric factors, their connexion with polyploidy, the phenomenon of pleiotropy and the relation between quantitative and qualitative characters must all be studied.

The Problem of Sex in Plants.

In spite of its great importance the subject has been little investigated. Recent work has proved the existence of a great number of types, both from the point of view of fertility and of morphological differentiation, within one and the same species. The old divisions into self-pollinating, cross-pollinating, self-sterile, self-fertile, require radical revision. Even in obligatory cross-fertilizers like rye self-pollinating forms have now been found. The vine has revealed a great range of variation in sex characters.

It is no longer Utopian to think of obtaining bisexual forms from dioecious plants such as hemp. From the point of view of breeding methods and the study of sex in plants it is of great moment to establish the amount of variation which exists in different cultivated plants.

The problem of self-fertility and sterility has particular significance in fruit trees, especially at the present time when millions of hectares are being planted, and it is necessary to choose the most suitable combinations of varieties.

In plants sex is often dependent on external factors. Experiments of Lyssenko have shown that the action of differences of temperature in wheat have changed a bisexual into a unisexual plant (the anthers fail to mature). The effect of chemical, physical and biological factors on sex reversal also requires investigation.

Floral Biology in Relation to Breeding Methods.

Attention must in the future be given to the floral biology of different cultivated plants, the type of flowering, extent of variation of the floral morphology, the mechanism of flowering, the agency and type of pollination, and also the influence of geographical factors on the floral biology.

The process of fertilization itself is not entirely clearly understood and many different types can be established. The time of maturity and period of activity of the pollen and stigma are of particular importance in hybridization, as are also the questions of spermatogenesis and oogenesis. Particular attention should be given to the genetic nature of self-sterility and fertility and cross-incompatibility, the different types of sterility (morphological, gametic, physiological, or sterility resulting from external influences).

Theory of Inbreeding.

The discoveries made in inbreeding work with maize, rye and other plants are too important to be neglected by the geneticist, e.g. the appearance of completely new forms, deviations beyond the limits not only of specific, but of generic differences, the appearance in bisexual plants of unisexual forms, etc. On account of the great variety of new forms arising by inbreeding, this is regarded as one of the most important processes of the origin of forms.

Application of the method to tea on quite a small scale evoked a variety of forms embracing the whole diversity of forms hitherto known to the breeder.

Problem of the Gene and Questions of Phenogenetics.

All genetics rests ultimately on the study of the gene. Gene balance, variability (mutability) the nature and origin of analogous and homologous genes, the genetic and physico-chemical structure of the chromosomes, the interaction of the genes in the chromosomes, the inactivation of parts of the chromosome, all these are momentous problems of modern theoretical genetics.

From the point of view of breeding, the study of the nature of recessive and dominant genes is the most important ; the preponderance of recessive mutations and the recessive nature of so many " cultivated characters " both demand a theoretical solution.

The interaction of the genes (hypostasis), cryptomery, modifiers, pleiotropy and other phenomena must all be subjected to further study in the near future.

The action of the gene in the mechanism of development, the laws governing the simultaneous action of polymeric genes and of genes antagonistic in ontogenesis, changes in the phenotypic expression of the genotype by external conditions, the mechanism of development of the characters and the action of the gene in different stages of ontogenesis — these are the fundamental problems of phenogenetics in the immediate future.

Problem of Origin of Cultivated Plants.

The study of the vast collections made in the last few years has shown that the complete subjection of the plant is dependent upon the investigation of the problem of the origin of cultivated plants, the establishment of the geographical localization of the process of the origin of forms, and the discovery of the laws governing this process.

In order to dispose of the potentialities of the cultivated plants and their nearest wild relatives these studies must be continued and embrace all species having any economic importance. In order to rationalize the breeding work, study should be made of the dynamics of the evolutionary process in space and time. An experimental study of the phylogenetics of cultivated plants should be made, together with the interrelationships between cultivated and wild species.

Further, modern genetics is taking a part in the work of the systematists, the botanist and in the solution of the general problems of evolution, and it is time for the botanist to give serious attention to genetics. The connexion established by the Scandinavian school of botanists between taxonomic studies and genetics and cytology has given brilliant results leading to the understanding of the evolutionary process in nature.

Common problems of modern botanists are the experimental investigation of the species, the processes of mutation and hybridization in nature, the action of natural selection and the occurrance of adaptation. Since species constitute complex populations they should be investigated in this respect by the differential method in the light of modern genetics. Some of the most interesting problems for experimental study are the problem of the plasticity of the species, the variability of the species, the amplitude of intraspecific diversity and the adaptability of the species to different conditions of the medium.

PLANT BREEDING PROGRAMME.

General Genetics.

Problem of Gene.

(1) The origin and structure of gene (genomery, subgenes, physico-chemical nature of gene).

(2) Genetical and physico-chemical structure of chromosomes (interrelation of genes in chromosomes, inactivation of parts of a chromosome).

(3) Gene balance.

(4) Variability of a gene (mutability, etc.).

(5) Problem of growth and multiplication of genes.

(6) The nature and origin of analogous and homologous genes.

(7) The nature of recessiveness and dominance.

Phenogenetics.

(1) Methods of phenogenetic (morphogenetic and physico-genetic) analysis.

(2) The mechanism of development of characters and action of genes at different stages of ontogenesis.

(3) Laws of individual and group variability of characters in phenogenesis.

(4) Laws governing the inheritance of characters of ancestors in ontogenetic offspring (recapitulation—biogenetic law).

(5) Variation of phenotypical expression of genotype in relation to various external conditions.

(6) Characterization of process of origin of forms by methods of morphogenetic analysis.

(7) Laws of mutual action of polymeric and antagonistic genes.

(8) Interrelation of genes (hypostasis, epistasis, cryptomery, modifiers, pleiotropy, etc.).

(9) Nature of action of the gene in the mechanism of development (curves and field of gene activity).

Artificially induced mutations.

(1) Factors of interrelation.

(2) Physiology of the process.

(3) The nature of mutational variations.

(4) Direction of mutations.

(5) Vegetative mutation.

(6) Relation with hybridization.

(7) Relation with inbreeding.

(8) The significance of the gene itself.

(9) Comparative genetics of mutations in various objects.

(10) Study of mutations in nature (the significance of geographical factors).

(11) Types of mutations and their interrelation under various influences.

Distant hybridization.

(1) Problems of crossing. (The cause of difficulties in crossing, increasing of crossing capacity by means of physiological and other influences, multiplication of chromosome complex by method of " polygenomous hybrids," etc.

(2) Infertility of hybrids and methods of its control. (Amphidiploidy, physiological influence, grafting, etc.).

(3) Study of laws of segregation. (Heredity of groups of characters, problem of obtaining forms with few characters from one parent, interrelation of genoms, etc.).

(4) Study of genetic nature of specific differences. (Plasmon, questions related to homology of specific chromosomes, homology of gene, etc.).

(5) Character of reduction division in relation to their segregation. (Methods of differentiation of specific chromosomes of hybrids (shape and size of chromosomes, differences in coloration), micro- and mega-sporogenesis, various types of chromosome aberration, etc.).

(6) Variation of chromosomes under the influence of distant crossing.

(7) Differences between direct and reciprocal crosses. Main material: wheat, rye, *Aegilops*, *Agropyrum*, maize, teosinte, sorghum, sudan grass, Cruciferae, tobacco, vetch, poppy, cotton, fruit crops, grapes, potato, oats, beet.

Crossing of geographical races.

(1) Crossing of geographically distant races as a method of finding the range of natural variation and possibilities of the origin of forms within the whole species.

(2) Finding combinations of geographical races of value in improving existing varieties by genetic methods.

(3) Selection of geographical races with the object of synthesizing fertile forms with such valuable characters as immunity, resistance to drought and cold, etc.

(4) In order to increase breeding possibilities it is necessary to include extreme forms of a species as well as the corresponding wild-growing relatives of cultivated plants.

The problem of sex.

(1) Sex determination: (a) chromosome complement as a determinor of sex in plants; (b) plasmatic inheritance of sex; (c) sex dimorphism; (d) sex differences in relation to age; (e) gynandromorphism and secondary hermaphroditism; (f) dimorphism of gametes; (g) problems of investigation of sex limitation.

(2) Development of sex: (a) influence of various factors on the process of development of sex; (b) influence of glands of internal secretion in sex formation; (c) sexual balance; (d) dynamics of sex differences; (e) influence of chemical, physical and biological factors on the development and formation of sex; (f) utilization of polyploids in changing sex.

(3) Chemistry of sex differences.

(4) Evolution of sex.

Heterosis, inbreeding, self-sterility and self-fertility.

(1) Nature of heterosis. (Genetic nature of heterosis, the presence of physiological, biochemical and biophysical factors).

(2) Genetics of phenomena accompanying inbreeding and its significance in the origin of forms.

(3) Influence of female organism on embryo in heterosis.

(4) Genetic nature of phenomena of self-sterility, self-fertility and cross incompatibility.

(5) Various types of sterility (due to morphological structure of flower), sterility of gametes, physiological incompatibility induced by external conditions.

(6) Theoretical elaboration of methods for the rapid achievement of homozygosis (system of crossing, self-pollination, parthogenetic development).

(7) Elaboration of methods of enforced self-pollination of self-sterile plants (pseudo-fertility).

(8) Restoration of sexual ability by method of vernalization.

Chromosome formation.

(1) Study of structural continuity of chromosomes.

(2) Elaboration of methods of determining internal structure of chromosomes.

Evolutionary changes of chromosomes.

(1) Study of specific karyotypes of all principal cultivated plants and animals.

(2) Further study of methods of determining morphology of chromosomes.

(3) Improvement of karyosystematic methods in zoology.

(4) Study of forms and types of conjugation.

Problem of chromosome combinations.

(1) Chromosome combinations in distant hybridization, crossing geographical races, in polyploid and chromosome aberrations.

Experimental transformation of chromosomes.

(1) Study of types and laws in transformation of chromosomes by means of X-rays.

(2) Determination of homozygous races with altered chromosomes and study of their genetico-phyletic characters (sexual isolation, etc.).

(3) Study of reduction division of chromosome aberrants.

Physico-chemical basis of heredity.

(1) Investigation of physico-chemical basis of hereditary variations of chromosomes.

(2) Mechanism of cytological realization (study of cytoplasmatic mechanism of hereditary realization ; determination of functional, physico-chemical and genetic nature of cytological structure of plasma.

Study of polyploidy.

(1) Methods of obtaining haploid, polyploid and amphidiploid forms (influence by external factors, interspecific hybridization, genes of reduction division).

(2) Mechanism of generation of polyploid nuclei as a result of various external factors.

(3) Determination of polyploid forms in nature, discovery of laws of their geographical distribution and causes of their origin.

(4) Changes in the mechanism of inheritance of characters in relation to polyploidy of the nucleus.

(5) Changes in ability to cross by polyploid multiplication of chromosome number.

(6) Morpho-physiological investigation of polyploid forms (quantitative differences).

(7) Obtaining homozygous plants by means of doubling of chromosome complements in haploids.

Maternal and cytoplasmic inheritance.

(1) Study of types of cytoplasmic inheritance.

(2) Cytoplasmic inheritance and experimental embryology.

(3) Interrelation of nucleus and plasma in near and distant crosses.

Methods of studying variations and heredity in quantitative characters.

(1) Method of studying quantitative characters in self- and cross-pollinating plants and in animals.

(2) Influence of external factors on range and laws of variation in quantitative characters.

(3) The nature of multiple factors.

(4) Pleiotropy of factors for quantitative characters.

(5) Relation between quantitative and qualitative characters (question of signal-genes).

(6) Phenogenetics of quantitative characters and problem of growth.

(7) Comparative study of variation in quantitative characters of various groups.

(8) Relation of multiple factors to polyploidy.

Floral biology in relation to the methods of breeding.

(1) Types of flower.

(2) Range of variation of morphological structure of flowers.

(3) Mechanism of flowering.

(4) Modes and character of pollination.

(5) Time of maturity and period of pollen and stigma activity.

(6) Spermatogenesis and oogenesis.

(7) Process of fertilization.

(8) Influence of geographical factors on floral biology.

Problem of the origin of cultivated plants.

(1) Geographical localization of process of origin of forms.
(2) Laws of origin of forms in cultivated plants.
(3) Dynamics of evolutionary process of cultivated plants in time and space.
(4) Dominant and recessive characters in evolution of cultivated plants.
(5) Role of man in directing the origin of forms in cultivated plants.
(6) Problems of phylogeny of cultivated plants (interrelation of cultivated and wild species).

Note: (a) All principal field and garden plants should be worked out.
(b) This problem has to be worked out by a group of paleontologists, archeologists, historians and linguists.

Experimental study of origin of forms in nature.

(1) Experimental study of types of mutation and hybridization in nature.
(2) Natural selection and adaptation.
(3) Populations.
(4) Nature of plasticity.

Homologous and analogous variability.

(1) Nature of homologous and analogous variability.
(2) Relation of homologous variations with phylogeny and identity of influence of experimental factors on genotype.
(3) Methods of determining homologous variability in races which do not cross.
(4) Genetic study of homologous series in plants and animals.
(5) Study of laws and of parallel variations of quantitative and agricultural characters.

*Permanent modifications.**

(1) Determination of the nature and types of permanent modifications.
(2) Factors causing permanent modifications.
(3) Problem of transformation into mutations.
(4) Influence on mutability of organisms.
(5) Accurate records of time of duration of a permanent modification and cause of its disappearance.
(6) Determination of factors and duration of the preparatory period.
(7) Permanent modification in sexual and asexual propagation and in parthenogenesis.
(8) Analysis of causes of the sudden termination of permanent modifications on sexual reproduction.

Problem of chimaeras.

(1) Graft chimaeras. (a) obtaining chimaeras with the object of somatic combinations and formation of new agriculturally valuable qualities of external and internal components—principally to apply an immune surface tissue to agriculturally valuable but susceptible varieties; (b) obtaining chimaeras from suitable species and races of plants in order to elucidate general, agriculturally valuable questions of graft chimaeras, e.g. (i) mechanism of development, (ii) immunity and resistance, (iii) hardiness, (iv) precipitative relations of components, (v) condition of generative elements.

(2) Stimulative chimaeras. (Obtaining chimaeras by the action of energy in different forms, chemical influence, X-rays. This is aimed primarily at the experimental alteration of the external layer in genetically uniform individuals in order to increase their immunity and resistance to various external influences. This problem is as yet entirely theoretical.

(3) Natural chimaeras. The object is to study the (a) origin of forms occurring in this way, (b) segregation of natural chimaeras into components.

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* "Dauermodifikationen."

(4) Problems of natural and experimental transformation both of natural and artificial chimaeras of various structure, i.e. transformation of haplochlamids, dichlamids and trichlamids one into the other, and also the transformation of sectorial into periclinal chimaeras.

(5) Related to natural chimaeras is the question of vegetative mutations. First, the vegetative mutation of agricultural plants (potato, citrus, etc.) and ornamental plants should be subjected to study.

(6) In connection with graft chimaeras and the interrelation of graft components it is necessary to study the processes of healing of grafts.

(7) Comparative study of variation of plants in the grafted state and in the isolated state (in relation to the question of interrelation of graft components).

SPECIFIC CROP GENETICS.

(1) Cereals and Buckwheat.

Wheats.

(1) Genetics of winter resistance : (a) resistance to cold, (b) resistance to ice crust, (c) warm humid conditions, (d) waterlogging, (e) immunity to *Fusarium*.

(2) Vegetative period : (a) vegetative period, (b) winter type.

Note. Genetics of winter type is to be studied from two aspects, viz. with or without vernalization under natural conditions. Two stages of development of a winter crop are to be studied, viz. vegetative stage before ear formation and reproductive stage, after ear formation to wax ripeness. The latter falls into two sub-stages, viz. from ear formation to flowering, and from flowering to wax ripeness.

(3) Genetics of immunity :

Special attention should be devoted not to the immunity to various physiological races, but to the immunity of a whole group of wheats to a number of groups of various parasites. [Immunity to *Tilletia* ; *Ustilago* ; brown rust, yellow rust, stem rust, mildew, *Fusarium*, *Mayetiola destructor* Say, and *Oscinella frit.*]

(4) Problems of drought resistance.

(5) Problems of salt resistance.

(6) Problems of protein content and other chemical and biological character of grains. Basal elaboration of theoretical grounds at I.P.I. Laboratory, Detskoe Selo.

(7) Problem of analysis of milling and baking quality of grain.

(8) Problem of heredity of characters related to the mechanization of agriculture : (a) lodging, (b) shattering, (c) fragility of ear internode and connected with this ear breaking.

(9) Problem of heredity of specific characters ; inheritance of the shape of ear in relation to the productivity and uniformity of seeds, as well as in study of winter forms in connexion with resistance to cold (Saratov).

(10) Heredity of response to various chemical factors and various methods of cultivation.

(11) Genetics of interspecific hybrids :

- (a) *Triticum dicoccum* × *T. vulgare* (with special reference to immunity to fungi and frit fly).
- (b) *T. dicoccum* × *T. turgidum*.
- (c) *T. dicoccum* × *T. durum*.
- (d) *T. durum* × *T. vulgare*.

Note. Study of segregations and origin of forms at the Saratov Institute, karyological study at the Odessa Institute, general questions with reference to immunity at the Omsk Station.

- (e) *T. vulgare* × *T. persicum* (with special reference to immunity.)

(12) Genetics of intergeneric hybrids :

- (a) *T. durum* × *Aegilops*
- (b) *T. vulgare* × *Aegilops*
- (c) *T. vulgare* × *Agropyrum*

(d) *T. durum* × *Agropyrum*

(e) Crossing of *Agropyrum* with various species and geographical races.

Note.

Special attention to be devoted to the inheritance of perennial habit and phenomena related to distant crossing ; cytological study ; questions related to cyclic crossings and origin of forms are divided between three institutions according to the geographical regions covered by them : (a) forms and races of humid submountains of Caucasus, (b) forms of steppe zones, (c) forms of West and East Siberia.

(f) Rye × wheats.

(13) Genetics of mutational processes :

(a) mutations in relation to distant crossing.

(b) ,, induced by X-rays.

(c) ,, ,, ,, other chemical agents.

(d) ,, in relation to chemical factors.

(14) Heredity of permanent modifications (influence of irrigation, geographical regions and soil types).

(15) Genetics of genus *Eutriticum*.

Note.

Special attention during the Five Year Plan should be given to monographical study of wheats based upon exhaustive collection of wild and cultivated forms. The object is to ascertain the significance of various geographical and ecological groups in breeding and experimental study of phylogeny of the genus *Eutriticum*. Investigation is based upon three chromosomal groups while wild growing species of wheat and *Aegilops* should be widely used.

(16) Genetics of hybridization processes. Geographical races. In 1933-37 special attention should be devoted to :

(a) Abyssinian species (with 28 chromosomes) and Transcaucasian endemic species. In study of Abyssinian wheats, special attention to be given to hard early forms and to awnless *T. turgidum*.

(b) Yemen (Arabia) hard wheats and emmer wheats, the earliest in the world.

(c) Groups of Syrian and Palestine hard wheats distinguished by excellent grains, early habit and drought resistance (Horan wheat).

(d) Wheat from Algeria, Tunis and Morocco should be widely used.

(e) Cyprus early *T. durum*.

(f) Wheat from Asia Minor. Special attention is to be given to their utilization in order to breed forms resistant to *Oscinella frit*.

(g) Mediterranean assortment of *Triticum durum* and *T. turgidum* should be revised in relation to the possibility of shortening its vegetative period by the methods of vernalization.

(h) For interspecific hybridization various geographical groups of emmer and spelt wheats especially resistant to diseases, such as Abyssinian, South European and Spanish groups, should be used.

(i) Among early *T. durum*, Egyptian forms with hard straw deserve special attention in breeding.

(j) Special attention should be devoted to *T. persicum* in improving hard wheats. At the same time it is necessary to begin the genetic study of *T. durum* × *T. Timopheevi* which gives fertile hybrids.

(k) Soft wheat. Primary attention to be devoted to early habit and drought resistance of Afghan and Asia Minor forms. Special attention to be devoted to cold resistant spring wheat from Afghanistan and Persia and their hybrids with winter forms in order to breed cold resistant forms.

(l) Best selected standards of Australia, Argentine, U.S.A., Sweden and Germany should be included in genetic study.

(m) It is necessary to devote attention to new wheat varieties suitable for sandy regions and bred by Baur (winter forms).

(n) Italian soft standard wheats of Strampelli and others should also be used.

(o) Round grained wheat should also be taken into genetic study with the object of studying round-grain habit in order to breed forms with highly uniform rounded grain.

(p) Hybrids of Bavarian and Würtemberg forms related to *T. vulgare* should be studied.

Notes.

Physiology. Types of drought resistance. Discovery of indirect methods of its determination on a large scale. Study of physiological nature of hardening and sun scorch. Elaboration of methods of discovering forms resistant to hardening on a large scale. Hardening. Progress of hardening of winter forms. After-effect of direct freezing. Direct and indirect methods of determining cold resistance. After-effect of cold. Study of physiology of plants under the conditions of ice crust and excessive soil humidity. Physiology of damage under snow cover. Technique of acceleration of work. Obtaining several generations in a year. Greenhouses. Vegetative propagation. Growing of immature grains. Overcoming sterility and non-earing. Influence of vernalization. Methods of study of root system of cereals.

Physics. Determination of soil temperature under field conditions by thermo-electric methods. Determination of temperature of a plant by the same method.

Barley.

(1) Immunity: (a) *Oscinella frit* (in relation to " white spot").
(b) Types of smut (with special reference to *Ustilago*).
(c) Rust on winter barley.
(d) *Lema melanopus.*

(2) Vegetative period: genetics of earliness; (a) extending cultivation to extreme north; (b) extending cultivation to especially dry regions.

(3) Genetics of cold resistance and winter habit in winter barley.

(4) Genetics of resistance to drought in spring barley (in collaboration with anatomists and physiologists).

(5) Industrial characters: malting qualities: percentage of protein, starch, uniformity, size and hulling of grain.

(6) Characters in relation to mechanization of agriculture: (a) lodging, (b) shattering.

(7) Specific characters: (a) smooth awns, genetics of awns, awnlessness, reduced awn, shedding awn in relation to improving forage quality of straw; (b) awnless winter barley.

(8) Genetics of naked barley in relation to: (a) improving the food of the people; (b) high fodder value; (c) malting naked barley.

(9) Distant crossing.

(10) Crossing of geographical races: genetic study of various geographical groups on the basis of the world collection of barley, accompanied by the estimation of their breeding value.

(11) Problem of artificial mutations of spring barley.

(12) Linkage of morphological and vegetative characters of spring barley and study of heredity of new characters.

(13) Experimental study of phylogeny.

(14) Monographical study of genetics of barley (in collaboration with other branches of botanical science).

Oats.

(1) Immunity (in respect of species) to (a) *Tilletia* and *Ustilago* (b) leaf and stem rust, (c) new Siberian disease (yellowing, reddening).

(2) Vegetative period (in respect of species): extending northern limits of cultivation. Control of *Oscinella frit.* Control of drought.

(3) Resistance to drought (in respect of species).

(4) Technological characters: (a) chemical composition: fat and protein, (b) genetic analysis of chemistry of 42 chromosome oats (*A. sativa, A. byzantina, A. nuda*). Elaboration of methods in collaboration with chemists.

(5) Characters connected with mechanization of agriculture: (a) non-shattering, (b) non-lodging.

(6) Specific characters: hulls, naked grain in relation to improving quality of product for culinary purposes.

(7) Quantitative characters: preliminary research: (a) productivity of ear, number of ears, (b) length of straw, (c) size of grain (the size of grain and pericarp).

(8) Interspecific hybridization: for breeding purposes and phylogeny (polyploids and polymery of oats).

(9) Artificial mutation: methods of obtaining mutations in oats for subsequent utilization in breeding.

(10) Factorial genetics: factorial analysis of hybrids between forms of equal chromosome number used in crossing between representatives of sub-sections.

Rye.

(1) Genetic study of characters connected with (a) mechanization of its cultivation, (i) enclosed grain, (ii) lodging; (b) specific characters and the size of grain.

(2) Inbreeding and heterosis: method of inbreeding and its genetic basis: (a) genetic study of self-sterility and self-fertility, (c) genetic grounds of heterosis.

(3) Study of variability of characters in relation to the methods of cultivation.

Maize and sorghum.

(1) Immunity: (a) ascertaining genetic factors governing resistance of maize to (i) smut, (ii) *Fusarium*, (iii) corn borer; (b) genetic nature of resistance of sorghum to (i) smut, (ii) bacterial disease.

(2) Vegetative period: genetic study of the length of vegetative period of maize and sorghum in various circumstances (vernalization, various ecological conditions of environment, namely, south, north, humid and dry zones).

(3) Chemical and technological characters: to establish the genetic factors governing the content of (a) protein, starch and fat in grain of maize and sorghum; (b) protein and sugar in stem of maize and sorghum.

(4) Mechanization: Genetic study of characters permitting wide application of machinery in harvesting maize and sorghum: (a) the height of ear formation in maize; (b) simultaneous ripening of inflorescences on a sorghum plant; (c) curvature of inflorescences; (d) non-shattering.

(5) Specific characters: genetic study of characters determining productivity, and quality of grain and green forage of maize and sorghum; (a) the height of plants, bushy habit, size of grain, amount of leaves, thickness of stem in maize and sorghum; (b) dimension of cross section of cob of maize; (c) presence of husk and colour of sorghum seed.

(6) Inbreeding and heterosis: (a) genetic characterization of initial material of maize for inbreeding; (b) elaboration of methods of obtaining haploids for accelerated production of homozygous highly productive lines of maize; (c) study of linkage groups in relation to the nature of heterosis.

(7) Interspecific hybridization: (a) teosinte × maize; (b) various species of *Andropogon*; (c) sorghum × sugar cane.

(8) Monographical study of maize: study of factorial composition of maize in relation to origin of forms.

Rice.

(1) Immunity to *Piricularia oryzae* and *Helminthosporium*.

(2) Vegetative period with the application of vernalization.

(3) Resistance in general. Resistance to salt.

(4) Technical properties. Long and solid straw.

(5) Mechanization. Tall habit. Non-lodging.

(6) Specific characters. Transparent grain; awns, large grain, type of panicle; character of endosperm.

(7) Interspecific hybridization.

(8) Crossing of geographical races.
(9) Mutations (study of various factors influencing mutation and genetic study of mutational processes).
(10) Heterosis.

Buckwheat.
(1) Vegetative period ; early and uniform ripening.
(2) Quantitative characters : large seed.
(3) Characters connected with mechanization of agriculture : shattering.
(4) Specific characters : (a) presence of husk ; (b) constancy of fruiting ; (c) study of flower structure, sterility and fertility.

(2) Pulses.

Pisum.
(1) Crossing species and geographical races in order to make genetic study of (a) vegetative period, (b) early forms for the North (c) extending the limits of vegetative period of garden crops.
(2) Mechanization of cultivation : (a) the height of insertion of the first pod, (b) space between fruit bearing nodes.
(3) Specific characters : (a) in respect of seed : large size, colour, shape, compactness and thickness of seed coat, (b) forage value : the height of the plant, branching, rate of growth, (c) culinary value : the content of dry matter in seed, parchment layer, sugar content in sugar beet, thickness of walls in sugar peas.

Vicia.
(1) Crossing of the following species : (a) *V. sativa* × *V. angustifolia brahisomica* to obtain vigorous and tender forms ; (b) (*V. sativa* × *V. amphicarpa*) × *V. angustifolia* to obtain vigour, early habit and firmness of plant ; (c) polyploids—interspecific crossing of vigorous forms ; (d) F_1 of vigorous growth produced by heterosis (by Jorgensen's method and temperature influence) ; (e) *V. sativa* × *V. villosa* to obtain winter habit.

Phaseolus.
Crossing of geographical races with the object of genetic study.
(1) Vegetative period ; early forms.
(2) Specific characters : colour of grain, its shape, size and compactness.
(3) Mechanization : the height of insertion of the first pod, self-opening pods.

Lathyrus.
Interspecific crossing for genetic study of :
(1) Drought resistance.
(2) Vegetative period.
(3) Specific characters : (a) bean value : colour and size, (b) forage value : branching.

Cicer.
Interspecific crossing :
(1) Drought resistance. *C. arietinum* × *C. spinutifidum*.
(2) Early ripening. *C. arietinum* × *C. judaicum*.
(3) Immunity to *Ascochyta*.
(4) In relation to mechanization : height of pods above ground.
(5) Specific characters : in respect of seed : large size.

Lupinus.
Interspecific crossing for subsequent genetic study :
(1) Vegetative period : early form (extending northern limits).
(2) Specific characters : alkaloid-free types.

Soya.
(1) Immunity to *Fusarium*.

(2) Resistance to drought : (a) resistance to atmospheric dryness during flowering and pod formation ; (b) resistance to soil dryness.
(3) Vegetative period : early habit.
(4) Chemical characters : (a) oil content, (b) protein content, (c) lecithin content, (d) content of protein in green plant.
(5) Industrial characters : quality of oil.
(6) Characters connected with mechanization : (a) the height of insertion of the first pod, (b) cracking of pods.
(7) Specific characters : flecking of grains.

Notes :
Phytopathology : study of racial composition of fungus and biology of its development.
Biochemistry : elaboration of simple methods of determining protein and lecithin content.

(3) Oil Plants.

(1) Resistance to *Fusarium* : obtaining resistant varieties (*Arachis* and *Sesamum*).
(2) Vegetative period : obtaining early forms *Arachis, Sesamum* and *Ricinus*.
(3) Technology : increased oil content and decreased acidity (*Sesamum, Arachis, Ricinus, Linum* and *Sinapis*).
(4) Characters connected with mechanization :
Ricinus : (a) single raceme, (b) height of raceme attachment, (c) uniformity of ripening, non-cracking fruits, elasticity of husk.
Arachis : (a) grouping of pods in cluster, (b) firm pod attachment, (c) smooth surface of pod.
Sesamum : (a) character of fruit dehiscence, (b) false septa, (c) the height of fruit attachment, (d) branching, (e) uniform ripening.
Linum : height of plant.
(5) Specifications : object of investigation : colour of oil and increased yield.
Sesamum : (a) colour of seed, (b) size, (c) the size of capsule, (d) firm attachment of capsule, (e) number of flowers on internodes.
Arachis : (a) the percentage of seed coat, (b) number of seeds in pod, (c) size of seed.
Carthamus (Safflower) : percentage of husk, (b) size of seed, (c) number of seeds in fruit.
Ricinus : (a) size of seed, compactness of raceme ; (b) number of fruits per raceme.
Linum : (a) size of seed, (b) of capsule.
(6) Distant crossing : *Carthamus* ; *Sinapis*.
(7) Crossing of geographical races : *Sesamum* ; *Ricinus* ; *Sinapis* ; *Linum*.
(8) Artificially induced mutations : *Sesamum* ; *Ricinus*.
(9) Mutation in relation to inbreeding : *Arachis, Sesamum*.
(10) Heterosis in relation to inbreeding : *Ricinus*.
(11) Problem of sex : *Ricinus*.
(12) Biology of flowering in relation to breeding methods : *Ricinus* ; *Arachis* ; *Carthamus* ; *Sesamum* ; *Linum* ; *Sinapis*.
(13) Problem of the origin of cultivated plants : *Ricinus* ; *Sesamum* ; *Arachis* ; *Carthamus* ; *Linum*.
(14) Natural selection : *Sesamum* ; *Carthamus* ; *Linum*.

Sunflower.
(1) Immunity : (a) genetics of immunity to *Orobanche cumana* in various species of the genus *Helianthus* ; (b) genetics of immunity to *Verticillium* ; (c) genetics of resistance of sunflower to *Homeosoma nebulella*.
(2) Resistance to cold. Study of inheritance of resistance to low temperatures during (a) early stages of plant development ; (b) flowering in relation to extending cultivation northwards and eastwards.
(3) Resistance to drought. Study of inheritance of resistance to high temperatures and phenomena related to drying winds at various stages of development.

(4) Vegetative period. Study of factors conditioning early maturity in various species and forms of *Helianthus* under normal conditions and in relation to vernalization and photoperiodism in order to advance its cultivation northwards and eastwards and its utilization in crop rotation.

(5) Chemical properties. Study of inheritance of oil content.

(6) Industrial (technological) characters.

(7) Characters connected with mechanization. Study of heredity of characters and degree of non-shattering (compactness of inflorescence).

(8) Specific characters related to its cultivation. (a) Study of inheritance of character of germination and development of seed in relation to sowing in late autumn ; (b) study of heredity of factors affecting fineness of pores ; (c) study of branching and its inheritance in order to breed well-branched forms of value in practice ; (d) Heredity of characters of colour and shape of ray florets and seeds, as systematic characters in order to produce ornamental forms as well as indicators of varietal peculiarities in varietal testing.

(9) Interspecific hybridization : (a) Study of origin of forms in hybridization of annual and perennial species and within the annual species ; (b) elaboration of methods of increasing crossing capacity in species of the genus *Helianthus* ; (c) genetico-cytological analysis of cyclic crossings.

(10) Methods of inbreeding and genetical foundation : (a) Heredity of self-sterility and self-fertility ; (b) genetical basis of heterosis in sunflower ; (c) fixing forms showing heterosis in offspring.

(11) Problem of induced mutation : (a) Genetic study of mutations induced by influence of inbreeding ; (b) mutation under artificial influences (monofactorial and vegetative) ; (c) genetical study of fasciation in sunflower ; (d) heredity of one-sided sterility with reference to breeding.

(12) Problem of graft hybrids and of regeneration in sunflower.

(13) Special questions : (a) possibility of obtaining haploids ; (b) possibility of obtaining apogamous forms ; (c) study of phenomena of maternal inheritance ; (d) phenogenetic heredity of constant inbred forms under various ecological conditions (variability and heredity of characters).

(14) Monograph on genetics of sunflower.

Note.—As a cross-pollinating plant, sunflower represents a compound hybrid organism, the genetic composition of which is accidental and inconstant in character and depends to a considerable extent upon the conditions of environment (by this the varietal composition of sunflowers cultivated in this or that region should be understood), or upon the collection of various forms and species of sunflower, sown in botanical gardens, as collection material. Genetic work and investigation along these lines therefore may be carried out only with inbred forms in which the homozygosity of the characters studied has been verified by a more or less protracted period of inbreeding.

(4) Essential Oil Plants.

(1) Study of heredity of specific chemical compounds. (a) Crossing of camphor basil *Ocimum basilicum* with common species ; (b) crossing of large-fruit with small-fruit races differing in essential-oil content ; *Coriander, Carum.*

(2) Interspecific hybridization : (a) crossing between sage and lavender species ; (b) study of genetics of character of specific systems (essential oils, resins) in order to breed new essential oil forms (sage, lavender, *Ocimum basilicum*).

(3) Artificial induction of bud mutations in lavender and geranium, with reference to influence of mutation on composition and yield of essential oils.

(4) Polyploidy by Winkler-Jorgenson method : (a) lavender ; (b) rose (with reference to study of influence of polyploidy on the composition of essential oils) ; (c) geranium.

(5) Biology of flowering in relation to methods of breeding : lavender, *Foeniculum, Carum, Ammi.*

(6) Inbreeding, self-sterility, self-fertility ; muscat sage ; lavender ; camphor basil ; coriander ; aniseed.

(5) Medicinal Plants.

(1) Study of immunity to *Peronospora* in valerian.

(2) Study of genetics of specific chemical compounds : (a) opium poppy (alkaloids) ; (b) medicinal valerian (essential oil).

(3) Interspecific hybridization for subsequent study of genetics of specific synthesis : (a) crossing of *Digitalis* species ; (b) crossing of mint species (peppermint, Japanese, green, water, field and *pulegium*) ; (c) crossing of opium poppy with perennial forms.

(4) Artificial mutation in relation to the study of influence of mutation on chemistry of plants ; opium poppy, *Hydrastis*, gentian, rhubarb.

(5) Polyploidy by Winkler-Jorgensen method in the study of its influence on chemistry of belladonna.

(6) Study of heterosis in relation to chemistry of camphor laurel and belladonna.

(7) Study of biology of flowering with reference to breeding methods : camphor laurel, *Digitalis*, belladonna, valerian, rhubarb, gentian.

(8) Inbreeding, self-sterility and self-fertility : medicinal valerian, red foxglove.

Note.

Chemistry : elaboration of chemical microanalysis of effect of medicinal and aromatic plants.

(6) Stimulants.

Tobacco.

(1) Immunity and resistance to bacterial, fungous, virus and insect diseases.

(2) Vegetative period : long-day and short-day habits ; leafiness, earliness.

(3) Chemical characters : nicotine, essential oil and resin (aromatic substances), carbohydrates, protein and oil in seed.

(4) Industrial characters : enzymes affecting the process of drying and fermentation.

(5) Characters connected with mechanization : general appearance, number of leaves, uniform ripening, properties of material for sowing, drought resistance, etc.

(6) Specific characters : size of plant, yield of leaves, colour, length, width (shape), solidity and elasticity of leaves, ratio between leaves and stalk.

General genetics of tobacco.

(a) Interspecific hybridization : (i) initial material, (ii) crossing of species, (iii) infertility, depression, heterosis of hybrids, (iv) homologous chromosomes, polyploidy, transference of genes, mutation of hybrids, (v) haploidy, (vi) fertile forms and combination of useful characters.

(b) Crossing of geographical races : (i) initial material and establishment of type, (ii) phenomena of heterosis, (iii) new combinations of characters.

(c) Artificial mutation : (i) physical, chemical and mechanical influences, (ii) biological influences, (iii) mutations of practical value.

Notes :

Physiology. Study of the physiological character of various strains, control of vegetative period, study of *Orobanche cumana*, mosaic and other virus diseases.

Chemistry. Determination of quality in respect of chemical composition, method of quick determination of chemical substances in living plant and in final product, method of fixation of material for chemical analysis.

Cytology. Determination of number of chromosomes in species, morphology of chromosomes, methods of determination of various chromosomes in hybrids.

Tea.

(1) Resistance to cold.

(2) Self-fertility.

(3) Vegetative period : duration of annual vegetative activity.

(4) Chemical properties : theine, tannins, proteins and aromatic substances.

(5) Technological properties : (a) difference in hereditary composition of enzymes influencing the process of drying and fermentation ; (b) the size of leaf influencing yield of varieties, rolling.

(6) Characters connected with mechanization : (a) uniform formation of flushes ; (b) their situation on upper surface of a bush (c) density of espaliers.

(7) Specific characters : (a) colour, size and shape of leaves ; (b) capacity for vegetative propagation ; (c) early flowering ; (d) capacity to reproduce by seed.

General questions.

(1) Interspecific hybridizaton : (a) to establish the crossing capacity of species of the genus *Camellia* ; (b) to find useful hybrids in respect of their fruiting or abillity to be vegetatively propagated.

(2) Crossing of geographical races : (a) collection of initial material ; (b) hybridization of northern and southern races ; (c) finding cold-resistant large-leaved hybrids and their vegetative propagation ; (d) heterosis and depression ; (e) production of cold-resistant homozygotes.

(3) Inbreeding : (a) to find methods of self-pollination ; (b) depression ; (c) self-sterility ; (d) to establish cross-fertile races.

Notes.

Physiology : Determination of cold-resistance, study of processes of self-fertilization, study of capacity for vegetative propagation, study of the influence of photoperiodism on growth, flowering and resistance to early frosts.

Chemistry : Study of chemical composition of various forms, determination of relation between chemical composition and quality.

Biochemistry : Study of enzyme content and determination of relation between enzyme content and progress of industrial processes.

Technology : Elaboration of laboratory method of technological treatment of green leaves.

Cytology : Study of chromosome complement of races and species, discovery of homologous chromosomes in various forms and morphological difference between chromosomes of various forms and species.

(7) Herbage Plants.

(1) Immunity to rust ; *Agropyrum* spp.

(2) Vegetative period. Rate of development in relation to productivity and aftermath formation. (a) red clover ; (b) blue lucerne ; (c) yellow lucerne ; (d) *Agropyrum* ; (e) *Festuca.*

(3) Chemical characters. Sweet clover (investigation of inheritance of coumarin).

(4) Fertility and self-fertility to accelerate breeding and improve seed production. (a) red clover ; (b) blue lucerne ; (c) yellow lucerne ; (d) vetch : *Vicia sativa* × *V. angustifolia* ; *V. sativa* × *V. angustifolia* × *V. amphicarpa.*

(5) Interspecific hybridization of blue and yellow lucerne ; (a) blue lucerne ; (b) yellow lucerne.

(6) Crossing of geographical races : (a) blue lucerne.

(7) Inbreeding : (a) red clover ; (b) blue lucerne ; (c) *Festuca.*

(8) Heterosis : *V. sativa.*

(9) Polyploids as result of hybridization and influence of temperature.

(10) Cytological study : *Agropyrum.*

(8) Roots and Tubers.

Potato.

(1) Immunity : Resistance to *Phytophthora* (study of genetics of anthracnose should be postponed because of quarantine).

(2) Resistance to cold.

(3) Resistance to drought.

(4) Problem of shortening vegetative period.

(5) Chemical characters : starch content.
(6) Industrial characters : accumulation of data for further breeding work.
(7) Problem of adaptation to mechanization : shape of tuber, plant and tuber clusters.
(8) Genetics of specific characters : genetics of sterility, breeding and genetics of varieties homozygous in respect of agricultural characters, genetics of principal morphological characters.

General problems.

(1) Problem of interspecific hybridization : (a) *Phytophthora* resistance : crossing *Solanum tuberosum* with *S. Antipoviczii* and related species : S. *demissum, S. verracosum* ; (b) resistance to cold : crossing of *S. tuberosum* with *S. acaule, S. Bukasovii, S. demissum, S. curtilobum, S. Juzepchukii, S. ajanhuiri* ; (c) early habit (preliminary selection of early forms) ; (d) distant crossing of species from the Andes and their various forms, with *S. tuberosum* in order to establish phylogenetic relations, to obtain chromosome aberrations and to study the process of the origin of forms, (e) cytological investigations of species, hybrids and mutants.
(2) Problem of mutational process : chromosome, generative and vegetative mutations, factorial mutations.
(3) Problem of heterosis : accumulation of data.
(4) Problem of inbreeding : accumulation of data.
(5) Problem of permanent modifications.
(6) Problems of heredity of provisionally quantitative characters.
(7) Problem of graft hybrids.

Notes.

Phytopathology : Elaboration of methods of determining *Phytophthora* resistance by examining various leaves and tubers.

Physiology : Elaboration of methods of determining cold and drought resistance by examining various leaves and tubers. Elaboration of methods of increasing fruiting, reducing period of rest and methods of winter cultivation of potato. Elaboration of simple methods of measuring transpiration, osmotic pressure, etc., for application on a field scale.

Anatomy, morphology, systematics, chemistry and technology : Search for characters correlated with characters of agricultural value. Elaboration of simple methods of determining chemical composition and technological characters on a large scale.

Jerusalem artichoke : Accumulation of data for further breeding work. Genetics of :—
(1) Immunity to *Sclerotinia libertiana* and other diseases.
(2) Inulin content.
(3) Protein content.
(4) Technological characters (ease and completeness of hydrolysis of inulin into fructose).
(5) Characters of tuber and stems suitable for mechanization.
(6) Interspecific hybridization (*Helianthus tuberosus* × *H. annuus*).
(7) Crossing of various geographical races.
(8) Early habit.

Sweet Potato : Accumulation of data for breeding work. Genetics of :—
(1) Cold resistance of tubers and storage qualities.
(2) Resistance to fungous diseases, more especially to *Fusarium*.
(3) Racial crossing.
(4) Tuber characters required for mechanization of its cultivation ; firmness of skin and the shape of tuber clusters.
(5) Capacity of starch to hydrolyse.
(6) Drought resistance.
(7) Earliness.
(8) Biology of flowering.

(9) Sugar Plants.

Sugar beet.
(1) Inbreeding : resistance to *Cercospora beticola*.

(2) Vegetative period : (a) annual habit ; (b) phases of development of seedlings ; (c) stages of development of sugar-beet in the first year.

(3) Chemical characters : (a) saccharose ; (b) monose ; (c) nitrogen ; (d) ash.

(4) Technological characters : (a) storing ; (b) study of loss of saccharose content in storage.

(5) Mechanization of agriculture : (a) Mechanization of digging out sugar beet, (i) shape of beet, (ii) emergence from soil, (iii) irregularity. (b) Mechanization of cultivation, (i) type of rosette, characters of petiole. (c) Mechanization of sugar beet cultivation by transplanting (i) shape of root, (ii) absence of irregularities. (d) Mechanization of harvest of seedlings, (i) type of plant, branching, density, (ii) non-shattering, brittleness of stem, (iii) uniform ripening of seed.

(6) Specific characters : (a) weight of roots and yield of sugar ; (b) racial characters of roots ; (c) number of rings of vascular bundles in root and of anatomical elements ; (d) characters of nodules and seed ; (e) elements of assimilating surface, character of leaf blade, nerves, etc. ; (f) pigment.

(7) Crossing of various geographical races : (a) crossing forms from Asia Minor, China and Western Europe in order to obtain early, drought resistant races and to find new allelomorphs for sugar content.

(8) Control of pollination : (a) heterosis ; (b) inbreeding (sterility and self-fertility) ; (c) elaboration of methods of enforced self-pollination.

(9) Acceleration of genetic work : study of flowering and fertilization in accelerated methods of genetic investigation.

(10) Interspecific hybridization : (a) genetic and systematic study of wild forms ; (b) karyotypes of *Beta* L. (number and shape of chromosomes) ; (c) hylogenetic study of segregation and processes of origin of forms in interspecific hybrids of *Beta vulgaris*, *B. trigyna*, *B. lomatoguna*, *B. macrorhiza* in order to obtain cold and drought-resistant, productive, immune and monospermous races of sugar beet.

(11) Polyploidy : hylogenetic study of heteroploid and polyploid forms to obtain productive forms.

(12) Experimentally induced mutations : (a) X-rays ; (b) wounding.

Chicory.

(1) Vegetative period : annual, biennial, triennial habit (in relation to producing pure biennial and triennial forms).

(2) Frost resistance : genetics of resistance (breeding winter forms).

(3) Chemical composition : genetics of inulin (increasing), N (increasing and decreasing)—intibin (increasing for coffee and decreasing for sugar production).

(4) Technological characters : woodiness and good quality sap.

(5) Mechanization : shape of root (obtaining short-rooted forms), uniform flowering, non-shattering seed.

(6) Specific characters : (a) shape of leaf in relation to yield, shape of roots and percentage of dry matter ; (b) pigmentation of leaf in relation to agricultural characters.

(10) Vegetables and Melons.

Tomatoes.

(1) Immunity to (a) bacterial diseases, (b) degeneration, (c) *Septoria*.

(2) Resistance to frost and cold : resistance to early frost.

(3) Resistance to drought : resistance to drought for advancing cultivation eastwards.

(4) Vegetative period : (a) study of genetic nature of early habit for extending the crop northwards and the requirements of the canning industry ; (b) production of perennial forms (interspecific crossing).

(5) Technological characters : (a) firmness of skin and its easy separation ; (b) structure of flesh ; (c) storage qualities of fruits (with reference to the requirements of the canning industry and transportability).

(6) Characters in connexion with mechanization of cultivation: (a) shape and strength of plant, shape of raceme, etc.; (b) uniform ripening of fruits on plant.
(7) Specific characters: (a) shape of fruit; (b) number of loculae.

General questions relating to tomatoes.
(1) Heterosis.
(2) Polyploidy.

Cabbages (*Brassica oleracea*).
(1) Immunity: Chilo.
(2) Resistance to frost and cold: resistance to early frosts.
(3) Vegetative period: (a) very early varieties, varieties which retain their quality; (b) annual habit; (c) bursting of the head.
(4) Characters connected with mechanization: (a) shape of head; (b) its compactness.
(5) Specific characters: (a) white colour; (b) internal stalk; (c) external stalk; (d) keeping quality (cabbage and cauliflower).
General items: (a) heterosis; (b) polyploidy.

Garden legumes (*Pisum sativum* and *Phaseolus vulgaris*).
(1) Immunity to: *Ascochyta* and anthracnose.
(2) Vegetative period: earliness (for extending cultivation northwards and for the requirements of the canning industry).
(3) Technological characters: marrow type of peas—structure of carbohydrates.
(4) Characters connected with mechanization: standard, leafy forms (cultivation without stakes), uniform fruit bearing.
(5) Specific characters—genetic nature of sugar pod of peas. Parchment and strings in *Phaseolus*.

Water melons and pumpkins.
(1) Immunity to anthracnose.
(2) Drought resistance: study of resistance to drought with the view to extending their cultivation eastwards.
(3) Vegetative period: early ripening for extending northwards.
(4) Technological characters: transportability, storage.
(5) Chemical characters: sugar content (glucose, saccharose, fructose).
(6) Characters connected with mechanization: shape of bush.
(7) Specific characters: (a) number of seeds in fruit; (b) thickness of flesh; (c) size of seed cavity; (d) shape of fruit; (e) flavour (in melons).
General questions: Heterosis in pumpkins.

Carrots.
(1) Immunity: *Sclerotinia*.
(2) Vegetative period: (a) study of genetic nature of earliness, for extending various culinary forms northwards and for the needs of the canning industry; (b) annual habit.
(3) Characters connected with mechanization: (a) shape, length and branching of root (in relation to various soil conditions); (b) shape, strength of plant, seeding; (c) uniform ripening of seed.
(4) Specific characters: pith.
General questions: (a) interspecific hybridization; (b) hybridization of geographical races.

Garden beet: *Beta vulgaris var. rubra.*
(1) Immunity: pith rot, scab.
(2) Vegetative period: (a) genetic nature of earliness (in relation to extending crop northwards); (b) annual habit; (c) failure to flower.

(3) Characters connected with mechanization: (a) shape, surface, branching of root; (b) shape and strength of seeding plant; (c) perennial habit; (d) uniform ripening of seed; (e) non-shattering.

(4) Specific characters: genetic nature of pigments and their distribution in various organs of the plant.

Onion (*Allium cepa*).

(1) Resistance to frost and cold: resistance to freezing (wintering of bulbs in the ground).

(2) Vegetative period: early ripening [industrial, (i.e., the rate of growth of bulbs) and botanical, (i.e., flowering and fruit formation)].

(3) Characters connected with mechanization: non-shattering seed and resistance to wind of seed plants.

(4) Specific characters: formation of cluster (number of bulbs in cluster), shape of bulb, type of cluster, colour of bulb, storage qualities.

Cucumbers.

(1) Winter and cold resistance: resistance to low temperatures at early and late stages of development.

(2) Resistance to drought: study of genetic nature of drought resistance.

(3) Vegetative period: genetic nature of early habit.

(4) Characters connected with mechanization: shape of plant.

(5) Specific characters: (a) parthenocarpy; (b) shape of fruit; (c) colour of green portion of fruit; (d) pubescence; (e) bitterness; (f) firmness of flesh.

(11) Small Bush Fruits.

A. General genetical problems.

(1) Interspecific (distant) hybridization: (a) hybridization of species of *Fragaria* with different chomosomes, associated with the study of the origin of forms and sterility; (b) hybridization between various species (sub-genera) of *Rubus* (between blackberry, raspberry, decorative and herbaceous raspberries) with interpretation of the processes of the origin of forms and sterility.

(2) Intraspecific hybridization (crossing of geographical races); (a) crossing of geographical races of *Fragaria vesca, F. collina, F. elatior.* Establishing the range of variation of characters and the processes of the origin of forms; (b) crossing of geographical races of *Rubus idaeus* (European, Siberian, Caucasian). Establishing the range of variation of characters and the processes of the origin of forms; (c) crossing of ecological Siberian races of *Ribes nigrum.* Establishing the range of variation of characters and processes of the origin of forms.

(3) Sterility, heterosis: (a) study of sterility of interspecific hybrids in *Fragaria, Rubus,* and *Ribes,* with application of cyto-embryological methods.

(4) Artificially induced mutations: (a) artificially induced mutations of *Fragaria* species with different chromosome numbers. Direction of mutations. Type of mutations. Comparative study of mutations of various species.

(5) Problems of sex: (a) production of bisexual forms in *F. elatior* and establishing the laws of inheritance of sex.

(6) Evolution: (a) experimental study of species of the genus *Rubus* and *Fragaria* in relation to problems of evolution of sex. Study of population with reference to geographical distribution.

B. Special genetics of small bush fruits.

(1) Immunity to: (a) *Sphaerotheca* (gooseberry): crossing of European large fruited varieties with American and wild species resistant to *Sphaerotheca* :— *Grossularia acicularis, G. oxycanthoides, G. hertella, G. divaricata, G. cynosbati.* (a) Study of immunity of strawberry to *Botrytis cinerea*: crossing of susceptible with immune varieties (Saxony, Victoria). (b) Study of

immunity of black currant to *Erysiphe ribes* Westw., crossing of resistant species of group " Miracle of Gironde." (d) Study of immunity of red currant to anthracnose : crossing with resistant forms : Red Holland, Honduki, Castle Houghton, Laturnice, London market, German yellow.

(2) Cold resistance : study of heredity in strawberry, raspberry and currants for extending their cultivation northwards (a preliminary to the next Five Year Plan) ; *Fragaria, Rubus, Ribes.*

(3) Drought resistance : study of heredity in strawberry, raspberry and currants for extending their cultivation into dry regions (preliminary to the next Five Year Plan) : *Fragaria, Rubus, Ribes.*

(4) Vegetative period : (a) production of varieties with brief period of fruit bearing ; genetical study of inheritance of this character for better rationalization of harvest : *Fragaria, Rubus, Ribes.* (b) Obtaining early and late varieties ; genetical study of these characters for extension of the time of fruit bearing : *Fragaria, Rubus, Ribes.*

(5) Study of inheritance of chemical and industrial characters : preliminary work on study of characters of transportability, storing and taste.

(6) Study of characters connected with mechanization of cultivation :— (a) breeding of gooseberry with erect bush and study of inheritance of this character ; (b) breeding of strawberry with short runner and genetical study of this character ; (c) breeding of black currant with compact bush ; genetical study of this character ; (d) breeding of thornless raspberry, blackberry and gooseberry and genetical study of this character.

(7) Study of specific characters : (a) study of heredity in *Fragaria* in respect of the length of spurs and bush ; (b) study of fruit shedding and uniform ripening of gooseberry (*Ribes*) ; (c) study of the size, colour and shape of fruit of *Fragaria* and *Rubus* ; (d) study of runner development in *Fragaria.*

Notes.

Physiology. Study of physiology of immunity. Elaboration of methods of study of cold resistance. Elaboration of methods of studying drought resistance. Physiological study of vegetative period.

Biochemistry and technology : study of appropriate characters.

(12) Fruit Trees.

Methods.

(1) Obtaining polyploids artificially by methods of regeneration and by crossing and inbreeding of triploids : apples, pears, citrus.

(2) Obtaining vegetative mutations by means of temperature, X-rays : peach, fig, cherry.

(3) Obtaining valuable chimaeras of grape and citrus. (Finding and studying vegetative chimaeras and mutations in all orchard and small fruit crops).

(4) Utilization of hybrid material obtained in breeding for studying problems of metaxenia.

(5) Study of influence of stock on scion and *vice versa*, including (a) influence of stock, disturbing the stages of vegetative development of the scion : apples and pears ; (b) influence of stock on reproductive system of scion and *vice versa* : peach, cherry, mountain ash ; (c) study of method of Mentor and vegetative approach.

(6) Study of permanent modification : pears, apples, cherries.

(7) Study of the unequal qualitative value of different organs within the ontogenetic system of the individual : apples, pears.

(8) Study of correlation between vegetative and agricultural characters.

(9) Distant hybridization : intergeneric and interspecific hybridization of citrus trees, intergeneric hybridization of pome and stone fruits (apples, pears, plums, mountain ash, hawthorn " irg," " mushmul") ; interspecific hybridization in *Malus* and *Pyrus.*

Special genetics of fruit trees.

Pears and apples.

(1) Immunity : resistance of apples and pears to *Fusicladium* and resistance of apples to woolly aphis.

(2) Cold resistance and later flowering.
(3) Dwarf habit, early and regular (annual) bearing.
(4) Time of ripening and keeping qualities of fruit.
(5) Size, colour, sugar content, acidity and consistency of flesh of fruits (preliminary).
(6) Parthenocarpy.
(7) Capacity to propagate by cuttings. With this object in view the following crosses should be made :

Crossing of cultivated apples with *Malus baccata, M. prunifolia* and other wild species in order to extend new varieties northwards.

Crossing of cultivated pears with *P. ussuriensis* and *P. serotina* and with drought-resistant species in order to extend improved varieties northwards and eastwards.

Cherries.

(1) Cold resistance and late flowering.
(2) Time of ripening for a correct distribution of workers during harvest time.
(3) Colour of sap in order to obtain varieties with dark coloured sap for industrial purposes.
(4) Size of stone in order to obtain small-stoned varieties.
(5) Dwarf habit of cherries with widely-separated branches for purpose of mechanization of harvest.
(6) Self-fertility.
(7) In research work local cultivated varieties should be crossed with *Prunus Chamaecerasus* and East Asiatic species.

Peaches.

(1) Immunity to " leaf curl " and to *Clasterosporium.*
(2) Cold resistance and late flowering.
(3) Time of ripening.
(4) Easy extraction and size of stone.
(5) Firmness of skin.
(6) Colour and consistency of flesh.

At the same time, interspecific crossing, inbreeding of genotypes of parent forms should be applied.

Citrus fruits.

(1) Immunity to scale insects.
(2) Size of trees for breeding dwarf forms for easy harvesting.
(3) Resistance to cold.
(4) Period of winter dormancy.
(5) Beginning of fruit bearing.
(6) Time of fruit maturity for breeding varieties with fruit with varying times of maturity.
(7) Size of fruit.
(8) Character of rind in order to breed easily skinned varieties.
(9) Seed content in order to breed small-seeded varieties.
(10) Acidity and sugar content : intergeneric and interspecific hybridization.

Notes.

Physiology. (a) Methods of accelerating fruit bearing in seedlings. (b) Physiological causes of unsuccessful distant crosses and methods of overcoming them. Physiological factors of self- and intersterility, germination of pollen and degeneration of megaspores. (c) Physiology of cold resistance and drought resistance. Elaboration of effective and convenient methods for estimating resistance to drought and cold. (d) Physiology of vegetative propagation (regeneration of cuttings). (e) Study of physiology of fruit bearing, and periodicity of pear and apple yield.

Special genetics of grape.

(1) Immunity : (a) *Phylloxera.* Breeding resistant varieties by method of cyclic crossing of *Vitis vinifera* with American species and obtaining generations up to F_2 and F_3 (with study of characters of *Phylloxera*). (b) Mildew. Breeding resistant varieties by method of cyclic crossing of *V. vinifera* with American species (obtaining generations up to F_2, F_3, and study of resistance to mildew). (c) *Oidium.* Breeding resistant forms by method of cyclic crossing of *V. vinifera* with American species (obtaining generations up to F_2 and F_3, and study of resistance to *Oidium*).

(2) Resistance to frost and cold. Breeding resistant varieties by means of crossing of *V. vinifera* × *V. amurensis* with study of this character.

(3) Vegetative period. Breeding early and later varieties (in order to extend their cultivation northwards) by means of intercrossing of *V. vinifera* and also by crossing with other *Vitis*.

(4) Chemical characters. Breeding of dessert varieties with transportability, varieties for wine and alcohol-free beverages (sugar and acid content).

(5) Specific characters : (a) preliminary work on study of characters related to transportability and storing ; (b) study of seedless varieties in order to obtain productive seedless strains ; (c) study of character of rooting in *Vitis*.

(6) Problem of sex. Study of heredity of sex in order to obtain self-fertile varieties.

(7) Self-sterility and self-fertility : study of self-sterility and self-fertility in order to improve yield.

(8) Permanent modifications : genetic study (yield of quantitative characters).

(9) The origin of cultivated plants : comparative genetics of wild *Vitis* species.

(10) Chimaeras : (a) study of chimaeras in order to find agriculturally valuable characters ; (b) production of chimaeras of practical value ; (c) qualitative inequality of ontogenetic system of individuals.

General genetics :

Vitis should be included in studies of inbreeding. *Phytopathology and entomology* : Methods of inoculation of seedlings with phylloxera, mildew and *Oidium*. Testing of seedling for resistance to phylloxera under various ecological conditions.

Physiology : Stimulation of seedlings and seeds to accelerated growth and fruit bearing.

(13) Fibre Plants.

Special genetics of cotton.

A. Genetic work in cotton growing for the second Five Year Plan which is in progress or to be commenced in 1932/33.

(1) Immunity : resistance to wilt in order to improve and increase the yield of Upland and Egyptian species and Americo-Egyptian hybrids : (a) acquired immunity ; (b) immunity as influenced by vernalization and time of sowing.

(2) Vegetative period with reference to improving yield and extending the crop into new regions : (a) early ripening (in relation to the height of formation of first sympodium) : Upland, Egyptian ; (b) vernalization : Upland, Egyptian.

(3) Technological characters : (a) the length of fibre with reference to improving and increasing yield : Upland, Egyptian, local cottons ; (b) fibre yield with reference to improving yield : Upland, Egyptian and Americo-Egyptian hybrids.

(4) Characters connected with mechanization : (a) shape of bush (extreme types of branching) : Upland, Americo-Egyptian hybrids ; (b) degree of dehiscence of pods : Upland, Egyptian ; (c) naked seed for mechanization of sowing : Upland.

(5) Specific characters : (a) percentage of ovaries shed with reference to increasing yield : Upland, Egyptian and local cottons ; (b) the size and shape of pod and number of faces as factors of yield ; (c) resistance to stormy weather.

B. General problems :

(1) Genetic monograph on cotton.

(2) Interspecific hybridization : (a) Upland × Egyptian in order to combine high yield

and high quality of fibre ; (b) Upland × local cottons in order to combine earliness, resistance to storms and yield ; (c) South-American perennial cotton × Egyptian cotton in order to obtain large-sized bolls in Egyptian. (It is desirable to effect also other combinations in order to obtain diversity in initial material for breeding).

(3) Crossing of geographical races of cotton in order to obtain the highest possible diversity of valuable combinations of agricultural characters : Egyptian, Upland, local cottons.

(4) Heterosis of Americo-Egyptian hybrids and an attempt to fix it in order to obtain high yield and high quality plants.

(5) Artificially induced mutations in order to obtain early, cold resistant and other valuable forms. Obtaining polyploid and polysomic forms.

(6) Biology of flowering in relation to problem of genetico-breeding work.

(7) Morpho-genetic analysis of agricultural characters from the point of view of the origin of forms.

(8) Non-heritable variations and permanent modifications.

C. Accumulation of data for subsequent genetic investigations.

(1) Immunity : (a) Resistance to gummosis : Egyptian, Upland.

(2) Resistance to cold : resistance to winter and autumn frosts.

(3) Resistance to drought : (a) drought resistance ; (b) Harmsile-resistance.

(4) Technological characters : strength, torsion and thinness of lint.

(5) Characters related to mechanization : (a) type of bush of Egyptian cotton ; (b) lateral shoots : Upland, Egyptian cotton ; (c) forms with reduced bracts.

(6) Specific characters : (a) resistance to salt.

Special Genetics of flax.

(1) Interitance of immunity : (a) to flax rust, (b) various races of *Fusarium* ; (c) anthracnose (*Colletotrichum*) ; (d) to a complex of fungous diseases (so-called flax-sick condition). (In connection with specialized cultural measures.)

(2) Inheritance of cold resistance : (a) resistance to spring frosts.

(3) Inheritance of vegetative period ; (a) genetic study of characters of early and late ripening with and without vernalization (for extending the crop northwards and eastwards and for growing two crops a year) ; (b) genetic study of character of accelerated development at the first stage of growth. (In connexion with need for early sowing as a control of flax flea-beetle and weeds and in connection with early harvest allowing second sowing).

(4) Inheritance of chemical composition : (a) percentage of fat in flax seed ; (b) iodine number ; (c) quantity and percentage of cellulose in fibre (in connexion with mercerization).

(5) Inheritance of technological characters : (a) percentage of fibre yield (in conjunction with various methods of agronomy) ; (b) characters affecting quality of fibre ; (c) quality for decortication ; (d) characters of mercerization (length of fibre, staple, fineness of fibre).

(6) Inheritance of characters valuable for mechanization : (a) non-lodging straw ; (b) height of stem ; (c) non-shattering capsules ; (d) shape of inflorescence ; (e) shape of capsule.

(7) Inheritance of specific characters : (a) type and shape of stem ; (b) foliage ; (c) study of genetic nature of varietal differences (small racial differences) in conjunction with varietal control and seed production ; (d) size of seed ; (e) number of seeds per capsule ; (f) genetic study of biology of flowering, and biology of spontaneous crossing (in connexion with methods of breeding).

General genetics of flax.

(1) Interspecific hybridization : (a) production of perennial forms of agricultural value ; (b) production of resistant forms.

(2) Crossing of distant geographical races in order to obtain forms productive both in fibre and oil yield in connexion with its dual use.

(3) Methods of obtaining artificial mutations. (X-rays, high frequency current, concentrated sun's energy, calcium, influence of temperature and regeneration).

Special genetics of hemp.

(1) Genetic study of geographically distant races (from south and central Russia in order to obtain more productive early forms).
(2) Genetic study of sex.
(3) Methods of obtaining artificial mutations.
(4) Heterosis.
(5) Inbreeding.

Special genetics of new bast crops.

Apocynum venetum L.

(1) Resistance to drought.
(2) Vegetative period—accelerated development of growth in order to grow two crops in one vegetative season.
(3) Quality of fibre ; yield and uniformity.
(4) Specific character : resistance to salt.
(5) Mechanization : uniformity of stems.
(6) Interspecific hybridization : *A. venetum* and others with *A. cannabinum*, *A. androssiemifolium* for resistance to cold and frost.
(7) Polyploidy : yield and quality of fibre.
(8) Artificial mutation (physical, chemical and biological factors).
(9) Biology of flowering.

Ramie *Boehmeria nivea.*

(1) Resistance to frost, winter and drought in connexion with extending the crop into new regions.
(2) Vegetative period : acceleration of growth in order to obtain three crops in one vegetative season.
(3) Quality of fibre : yield and uniformity.
(4) Interspecific and intergeneric hybridization with *B. nivea* and *B. tenacissima* in order to increase yield and improve quality of fibre, and with nettle species in order to extend the crop northwards.
(5) Specific problem : resistance to conditions under snow cover.
(6) Artificial mutations (physical, chemical and biological factors).
(7) Crossing with geographical races from China, Algeria, India, Transcaucasia, etc., in order to combine agricultural characters.
(8) Polyploidy : increasing and improving yield of fibre.
(9) Inbreeding : obtaining forms resistant to frost and cold.
(10) Heterosis, self-sterility and self-fertility.
(11) Problem of sex : obtaining monosexual, bisexual and hermaphrodite forms for breeding purposes and for obtaining F_1 on a large scale.
(12) Chimaeras, grafting, vegetative mutants.
(13) Problems of origin.

Hibiscus Cannabinus L.

(1) Immunity to *Botrytis* and *Fusarium*.
(2) Resistance to drought.
(3) Resistance to frost (spring frost).
(4) Vegetative period with or without vernalization.
(5) Quality of fibre.
(6) Interspecific and intergeneric hybridization with species of *Hibiscus* and *Malva meluca* to breed early varieties with length and quality of fibre.
(7) Crossing of geographical races in order to combine agricultural characters.
(8) Problem of artificial mutations (physical, chemical, biological factors) directed to quality and quantity of fibre.

(9) Polyploidy : directed towards quality and quantity of fibre.
(10) Permanent modifications.

Notes.
(1) *Technology and mechanization* : Elaboration of methods and construction of apparatus for quick and accurate mechanization of quality of fibre, its length, fineness, degree of lignification.
(2) *Botany* : Systematics of new bast crop.
(3) *Physiology* : Problem of damage under snow cover.
(4) *Anatomy* : Study of formation and development of bast fibre, of bast crops in respect of races, species and mutants.

(14) Forest and Ornamental Trees.

Special genetics and breeding.

(1) Immunity :
(a) Fungous diseases : (i) selection of pine races resistant to leaf cast ; (ii) selection of oak and mulberry resistant to *Oidium* : races of common, winter and downy-leaved oaks and white mulberry ; (iii) selection of races of pine and fir resistant to *Fusarium* : pine and fir trees ; (iv) selection of oak and pine races resistant to *Armillaria mellea* ; (v) selection of races of common oak resistant to *Polyporus seramosus* : races of common varieties ; (vi) selection of common pine races resistant to pine fungus : geographical populations of common pine, viz. northern races ; races of Central European part of U.S.S.R., Siberia and the Far East ; races of Ukraine, Crimea, Northern Caucasus ; (vii) selection of fir races resistant to *Polyporus anosus*.
(b) Bacterial diseases : selection of mulberry resistant to *Bacterium mori* : Japanese mulberry.
(c) Insect pests : selection of pine races distinguished by rapid regeneration of root system damaged by larvae of cockchafer, and study of this character : common pine races.
(2) Resistance to winter and cold : (a) determining winter and cold resistant races of timber trees in order to advance their cultivation north of their natural distribution : common oak, cork oak, ash, *Philodendron*, white acacia, mulberry, Douglas fir, walnut, *Eucommia* and other exotic trees ; (b) selection of races of timber trees resistant to frost in exposed regions : common oak, ash, white acacia, mulberry.
(3) Resistance to drought : (a) selection of resistant races of timber trees suitable for cultivation for industrial purposes and for formation of shielding strips in arid steppe regions : species and races of common, winter and downy oak, mulberry-tree, *Gleditschia*, acacia. Maple : field and pointed leaf. Ash : common and others ; (b) study of drought resistance of orchard ornamental forms used or capable of being used for parks in towns and in arid zones : various species and varieties of decorative trees.
(4) Hydrophylous species : genetic study of ability of various species and races of timber plant to resist excess of water in soil, having in view the reclaiming of boggy and marshy lands poplar, willow, alder, red and marsh oak, marsh cypress, larch, etc.
(5) Resistance to salt : (a) study of the ability of timber races and species, used in shielding strips, to resist excessive concentration of salts in soil : various species and races of oak, *Gleditschia*, acacia, mulberry trees, poplars, etc. ; (b) selection of species and races of timber plants most suitable for reclamation of salted soils : saxaul, poplars, oak, tamarisk, etc.
(6) Length of vegetative period : Selection of early and late races of various timber species valuable in agriculture : fir, pine, beech, oak, aspen, walnut and almond.
(7) Chemical composition : (a) to obtain timber races with an increased content of tannin (leaves, wood and bark) : acacia, fir and willow species ; oak, *Rhus cotinus*, chestnut, sumach and Austrian acacia ; (b) races of pine trees with increased production of resin for the rosin and turpentine industry : geographical races of pine ; (c) races of rubber-producing trees (exotic and indigenous) with increased rubber production : *Eucommia*, *Periploca*, " greca," etc. ; (d) productive races of oil trees ; cedar, beech, walnut, *Aleurites fordei*, eucalyptus ; (e) breeding more productive races of lacquer, camphor and other trees.

(8) Technological (physical) characters: (a) study of inheritance of technical characters in timber plants and production of highly productive forms (erect growth, few branches, structure of wood ensuring high technical qualities, etc.): pine, fir, birch, oak, ash, etc.; (b) races of cork trees with increased production of cork-bark: cork oak, "velvet tree", cork elm (*Ulmus suberosa*).

(9) Characters connected with the mechanization of industry: breeding mulberry trees with branching suitable for mechanized harvest of leaves.

(10) Specific characters of various plants: (a) obtaining rapidly growing forms of trees of high agricultural importance: pine, larch, fir, oak, ash, birch, alder, maple, walnut, poplar, willow, eucalyptus, bamboo, etc.; (b) willow races with high quality of withe for industrial purposes; (c) races of trees resistant to gas, dust, smoke and other excretions of industry: species and forms used for ornamental purposes (parks in towns); (d) selection of races resistant to wind: fir; (e) selection of races resistant to snow and soil erosion; oak, fir and pine; (f) fruit bearing trees with an increased fruit yield: walnut and chestnut, small bush fruits, leguminous trees, mulberry; (g) obtaining thornless races of trees for convenient and easy treatment of plantations: *Gleditschia*, white acacia and other ornamental timber and shrub plants; (h) thorny races of various trees for use in general plantations.

General questions.

(1) Introducing into forest and ornamental plantation new species and subspecies of trees (exotic and indigenous) for agricultural and ornamental purposes and for stores of genetic material.

(2) Crossing between various forms of trees of the same species (close crossing) for combination of characters of value in agriculture, more especially in those plants which propagate vegetatively.

(3) Crossing of geographical races of various trees for combination of the most useful agricultural characters with resistance.

(4) Interspecific and intergeneric crosses for producing new forms with improved characters of value in agriculture.

(5) Study of heterosis in trees and elaboration of method of its wide application for practical purposes; obtaining polyploids by vegetative and sexual (mutations) methods.

(6) Application of inbreeding for producing forms with recessive characters of value in agriculture and other purposes.

(7) Finding natural and obtaining artificial mutants in forest and ornamental trees.

(8) Discovering natural and obtaining induced chimaeras of trees of interest for ornamental purposes.

(9) Elaboration of methods and technique of breeding work with trees (hybridization, inbreeding, mutation, chimaeras, etc.).

(10) Elaboration of methods of accelerating rate of breeding work with trees (acceleration of fruit-bearing, vegetative propagation, etc.).

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